THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

Published by the SOCIETY OF AUTOMOTIVE ENGINEERS, INC., 29 *W. 39th St., New York*

J. H. HUNT, *President* COKER F. CLARKSON, *Secretary* C. B. WHITTELSEY, *Treasurer*

Vol. XXI October, 1927 No. 4

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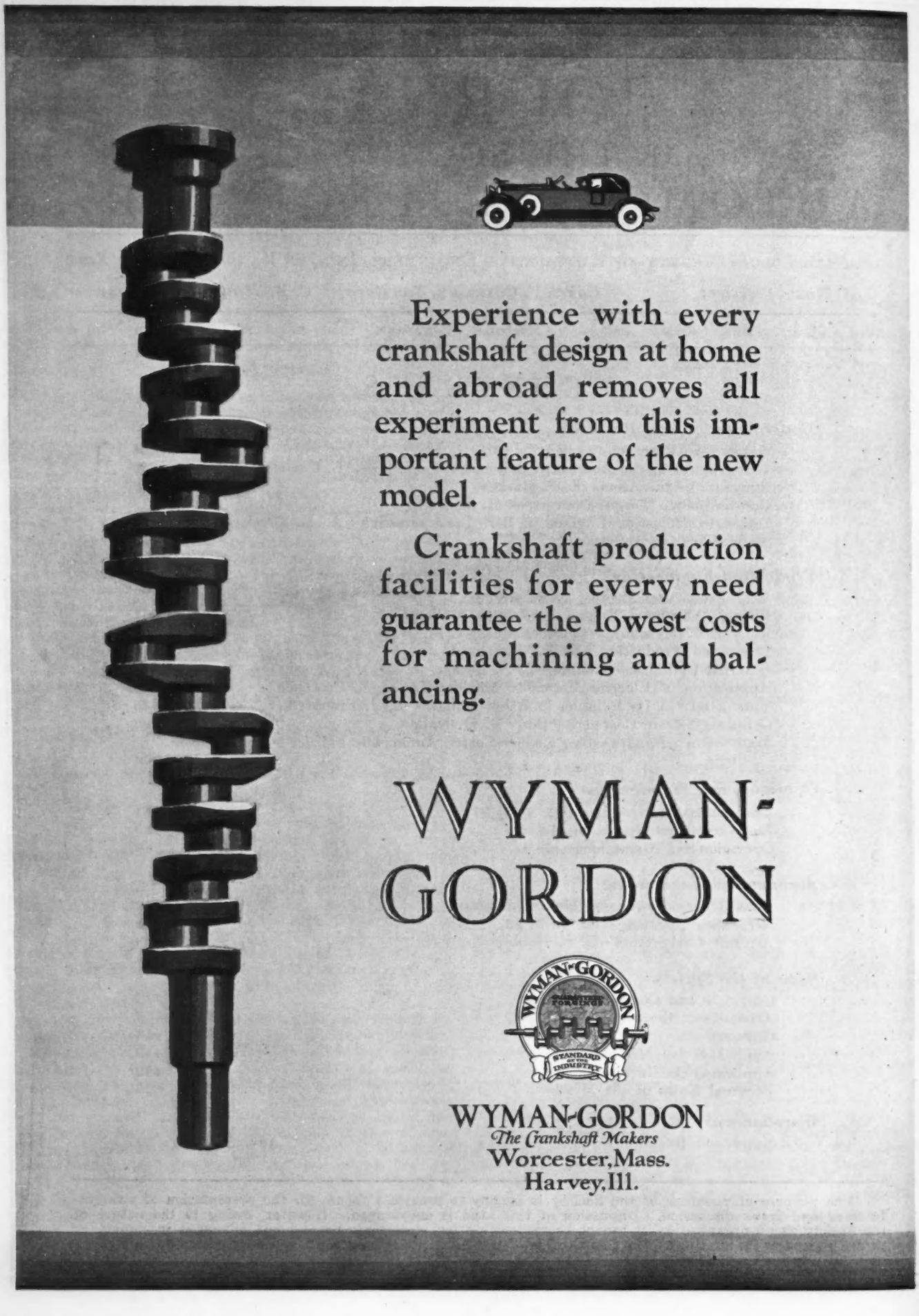
The purpose of meetings of the Society is largely to provide a forum for the presentation of straightforward and frank discussion. Discussion of this kind is encouraged. However, owing to the nature of the Society as an organization, it cannot be responsible for statements or opinions advanced in papers or in discussions at its meetings. The Constitution of the Society has long contained a provision to this effect.


Experience with every crankshaft design at home and abroad removes all experiment from this important feature of the new model.
Crankshaft production facilities for every need guarantee the lowest costs for machining and balancing.
WYMAN-GORDON
WYMAN-GORDON
The Crankshaft Makers
Worcester, Mass.
Harvey, Ill.

THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

Vol. XXI October, 1927 No. 4

Chronicle and Comment

The Aeronautic Meeting

THE technical program for the Aeronautic Meeting will be found in full on p. 350. This program should be all that is necessary to lead each member primarily interested in aeronautical engineering to decide to be in New York City on Oct. 18, 19 and 20 so that he can attend the sessions at the Waldorf-Astoria.

General Manager Visits West Coast Sections

COKER F. CLARKSON, in his capacity of Secretary and General Manager of the Society, is visiting the Northern and Southern California Sections, having attended at Spokane on Sept. 23 the Aeronautic Meeting of the Society, which is reported on p. 348 of this issue.

New Student Branch Proposed

MEMBERS of the senior class at the General Motors Institute of Technology are taking steps to form a student branch of the Society. A constitution has been drawn up by them for submission to the Council, the election of officers being deferred pending action of the Council.

The Production Meeting

THE high spots of the 1927 S.A.E. Production Meeting and of the exhibitions of the National Machine Tool Builders' Association and the American Society for Steel Treating will be found in the news account of the meeting beginning on p. 333. Many of the papers presented at the technical sessions also appear in this issue. Papers not so appearing are summarized in the news account.

The registration of practically 400 exceeds that of meetings of recent years, indicating the increasing importance of production engineering in Society activities. Credit is due John Younger who, with the members of his committee, was responsible for the very interesting and instructive technical program.

German Automotive Diesel-Engines

PARTICULARLY interesting, in view of the attention now being given to high-speed oil-engines, is a report on German automotive Diesels, recently compiled by Theodore Pilger, American trade commissioner at Berlin. It has been issued by the Automotive Division, Department of Commerce, as Economic and Trade Note No. 30.

Included in the report are catalogs and excerpts from German technical magazines which should prove of interest to students of this field of development. Among the products described in the catalogs are two engines of the Maschinenfabrik Augsburg-Nürnberg, one of Friedrich Krupp Aktiengesellschaft and two of Heinrich Kaemper Motorenfabrik Aktiengesellschaft. One of the articles in the group, published in *Der Motorwagen*, Jubilee Edition, 1926, is characterized as the most complete available survey of high-speed crude-oil engines for automobiles developed in Germany. Selections from *Der Last-Auto, Zeitschrift des Vereins Deutscher Ingenieure* and *Engineering Progress* have also been assembled.

Inquiries for more detailed information on the trade note may be addressed to H. O. Smith, chief of the automotive division, Department of Commerce, or to the headquarters of the Society.

The Transportation Meeting

THE S.A.E. Transportation Meeting brings together each year all engineers interested in transportation mediums utilizing the internal-combustion engine for motive power. The 1927 meeting will be held this month at the Hotel Sherman in Chicago, the dates being Oct. 25, 26 and 27. The complete program for the meeting will be found on p. 351. The Annual Transportation Dinner, for which reservations are now being made, will be held on Oct. 26.

Suggested Cooperation on Operation Subjects

INTERESTING suggestions outlined in the Operation and Maintenance department of this issue of THE JOURNAL are made by Ethelbert Favary, of Los Angeles, chairman of the Subcommittee on Education of the Committee on Operation and Maintenance, regarding Section and Subcommittee work. The object in offering these suggestions is to elicit comments and constructive criticism. These should be addressed to Mr. Favary, Box 317, Los Angeles.

Reading of the suggestions reveals that the broad idea is to draw out information from fleet operators and their service men and from factory service managers throughout the Country; correlate, sift, and condense all such information on each specific subject; and present the result at Section meetings, and to all Society members through THE JOURNAL. Thus a large volume of valuable information from practical men can be accumulated on each subject from all parts of the Country and the best of it can be transmitted to all the Sections and the membership in general.

Such a comprehensive plan, if put into effect and well carried out, should result in the greatest possible interchange of ideas; and the material, if completely analyzed and condensed, should avoid much duplication, save time at Section meetings and present the real meat of each subject.

If men can be found in the Sections and in the Operation and Maintenance Committee or the Subcommittee on Education who are willing to do the work outlined, good results ought to follow. Should the proposal as a whole be thought too elaborate, it may be feasible for execution in some abbreviated form. Mr. Favary is willing to shoulder a large part of the undertaking he proposes. It is evident that he desires consideration of and comment on the method and machinery of the plan as outlined and also to enlist the cooperation of the Committee members and officers of the Sections in putting it into effect.

Regulation of Oversea Flights

TOO much regulation by government over a developing science, art, or industry is detrimental to progress. This was unforgettably illustrated in the pioneer days of self-propelled road-vehicles in England, when the Road Locomotive Act of Parliament, meant to protect the public on the highways, so greatly restricted the use of road-vehicles that Continental and American inventors gained a lead over English developers that required many years to offset.

Now comes an insistent protest from America and Europe against the lamentable loss of life in transoceanic flights and urgings that measures be taken by some Government bureau or by the Congress to prevent more such attempted flights while the hazards are so great. Those within the industry realize that much, if not all, of the favorable public impression created toward aviation by the successes of last summer has been offset to a large extent by as numerous disastrous failures.

The three Assistant Secretaries for Aeronautics, F. Trubee Davison, Edward P. Warner and William P. MacCracken, Jr., of the War, Navy and Commerce Departments, constituting the Air Coordination Committee, after considering this subject, upon the suggestion of the President, at a meeting last month, announced that

> Notwithstanding and recognizing the serious hazards attached to transoceanic flights, the members of the Committee all agreed in not favoring any specific Governmental prohibition of pioneering flights.

The Secretaries hold, in their statement, that a special hazard is attached to the use of land planes for long-distance over-water flying; that seaplanes or flying boats are safer and better adapted for such use; that such flights should be discouraged except when undertaken by personnel competent to measure the risks involved, with the best possible equipment and the most careful preparation; that public opinion will act to this end and impose a restriction upon the offering of any direct incentive for making exceptionally hazardous flights without requirement of reasonable precautions; and that the War, Navy and Commerce Departments are ready at all times to advise with those proposing such trips on the difficulties and risks involved.

The chief present hazard of long oversea flights is weather conditions and the lack of sufficient reliable reports on storms, fog and temperature at sea. To assist in remedying this situation and "to advance the art and science of meteorology in aviation," the Daniel Guggenheim Fund for the Promotion of Aeronautics formed a Committee on Aeronautical Meteorology last month, to make its headquarters at the Weather Bureau in the City of Washington and to encourage and support investigation and direct attention to essential problems in this field.

Meteorological conditions are not the same over the land as over the ocean, and a great deal more reliable information on ocean weather phenomena is prerequisite to the establishment of transoceanic air-service. Navy flights by way of the Azores and to Hawaii and the transatlantic flights of De Pineda have demonstrated the greater safety of pontoon-equipped airplanes for long over-water voyages; but, in view of the successful flights this year with landplanes over both the Atlantic and the Pacific, the prohibition of more such attempts, even though it saved lives, might be unreasonably restrictive of bold ventures ultimately destined in the aggregate to further the development of cross-ocean air-service.

In the public interest, however, some regulation of such flights seems justifiable. Even if it is conceded that intrepid spirits have the privilege of risking their lives in hazardous attempts, the public doubtless has the right to protect itself against the heavy expenditures incurred by the Navy and the loss of time by passengers on ocean liners involved in searching the seas for lost fliers.

The Transactions

FROM time to time requests are received at the office of the Society for back copies of the TRANSACTIONS. The latest one is from the Patent Department of the National Automobile Chamber of Commerce for a copy of Part I of the 1924 TRANSACTIONS. No copies of this Part are available at the office of the Society, the supply having been exhausted almost as soon as the volume made its appearance in the fall of 1925. Should any member have a copy of this Part of the TRANSACTIONS which he does not care to keep, it will be appreciated if he will notify the office of the Society.

As this issue of THE JOURNAL goes to press, work in preparing the TRANSACTIONS for the first half of 1926 is actively under way both at the printers and in the office of the Publication Department. This volume which, it is expected, will be available about Dec. 15, will consist of approximately 700 pp. and will contain, by direction of the Publication Committee, certain papers presented at the 1926 Annual Meeting of the Society, other papers presented at Sections Meetings and contributed articles that were published in THE JOURNAL from January to June, 1926, inclusive, comprising a total of 27 papers and articles including discussions.

Volumes of the TRANSACTIONS are now sent only to members ordering them and paying the fee of $2 per Part. To be assured of receiving a copy of this Part, members should place their orders by Nov. 17. An order blank was enclosed with the *Meetings Bulletin* of Sept. 17. For the convenience of the members who may have mislaid or overlooked this blank, a TRANSACTIONS order blank will be found in the advertising section on p. 138.

To meet the wishes of members who desire to place a single order covering all future Parts of TRANSACTIONS instead of ordering each Part separately, a space is provided in this blank for such orders. These will be entered on a list to receive Parts of TRANSACTIONS as they are issued. Payment at the rate of $2 per Part for all copies ordered in this way is to be made upon presentation of a bill prior to the appearance of each Part.

HON. EDWARD P. WARNER

Meetings Calendar

Visit to Aberdeen Proving Ground
Oct. 6, 1927

Aeronautic Meeting
Oct. 18 to 20, 1927
The Waldorf-Astoria, New York City

Transportation Meeting
Oct. 25 to 27, 1927
Hotel Sherman, Chicago

Tractor and Stationary Engine Meeting
Dec. 1, 1927
Hotel Sherman, Chicago

Sections Calendar

Buffalo Section Meeting—Oct. 4, 1927
Lubrication—E. F. Hallock

Chicago Section Meeting—Oct. 11, 1927
Influence of Large-Scale User on Design and Construction of Automotive Equipment—R. E. Plimpton

Cleveland Section Meeting—Oct. 17, 1927
Notes on Valve-Spring Design—W. T. Donkin

Detroit Section Meeting—Oct. 10, 1927
A Message of General Interest—J. H. Hunt

Indiana Section Meeting—Oct. 13, 1927
Commercial Aviation—G. M. Williams and other speakers

Metropolitan Section Meeting—Oct. 20, 1927
See Aeronautic Meeting Programs for details

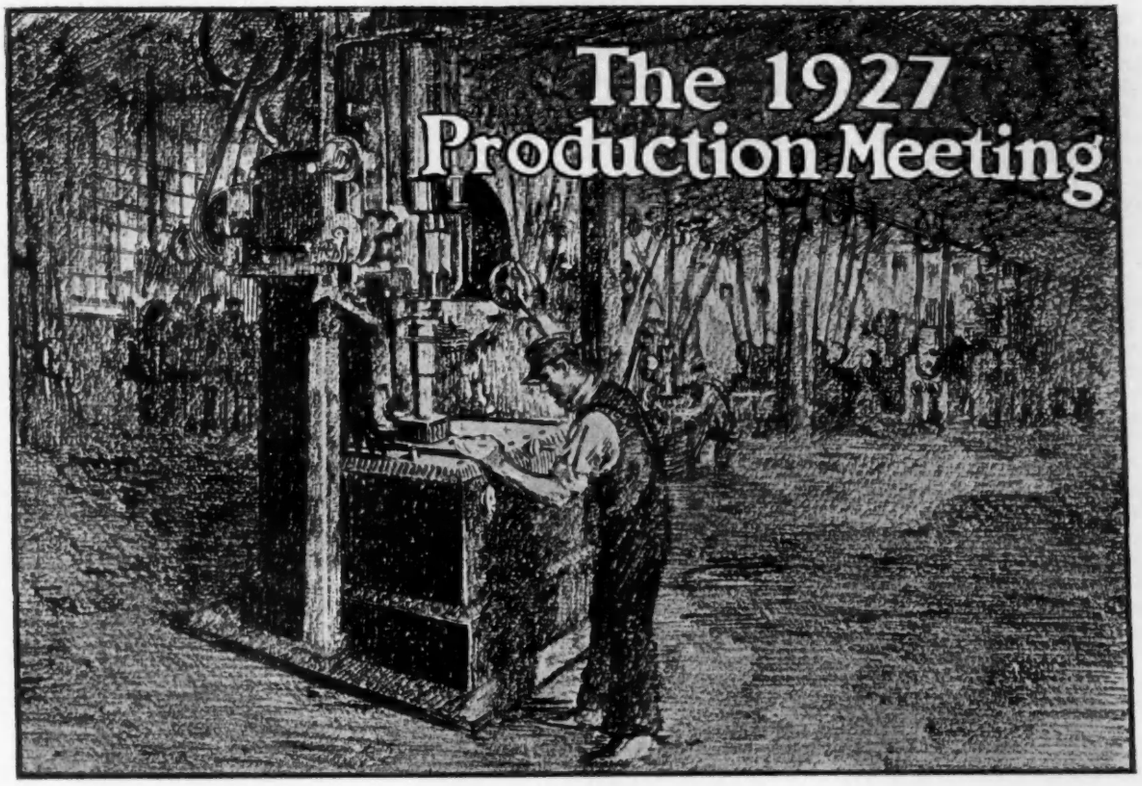
Milwaukee Section Meeting—Oct. 5, 1927
Recent Trends in Automobile-Tire Construction—Leon J. D. Healy

New England Section Meeting—Oct. 5, 1927
Visit to Boston Airport in the afternoon and paper on Modern Developments in Aeronautic Practice, by Walter F. Eade in the evening

Northern California Section Meeting—Oct. 9, 1927
Depreciation of Equipment on the Mileage Basis—Harold Jarvis

Pennsylvania Section Meeting—Oct. 6, 1927
Visit to Aberdeen Proving Ground

Washington Section Meeting—Oct. 5, 1927
Ordnance Automotive Developments—Major L. H. Campbell, Jr., U. S. A.



Cleveland Sessions and Exhibits Show Progress

When the tumult of the shouting ceased; when the noise of machinery and the smoke and confusion of the exhibits in Cleveland and Detroit had died away; when the startling bombs of new ideas and the whir of talk on new methods and processes for maintaining production with greater economy and closer accuracy had quieted down; there was no one to deny that National Steel Week had been a great week. The only casualties were represented by the men who tried to cover the whole program in too short a time, and they are now suffering from severe cases of mental indigestion.

To pick an outstanding feature of either the Cleveland or the Detroit exhibit, or of the programs which were presented, would be not only difficult but almost impossible at this time, for the effect of the new ideas and the new developments in machinery must be proved by consistent and practical service before their significance can be appreciated fully. Generalizing, however, there was very evident progress in steels and their treatment in furnaces, machinery and manufacturing methods that express a notable trend, not so much toward greater production as toward greater economy in a production volume which should be maintained in order to support the present and intended investments in manufacturing equipment.

One thought often expressed among the visitors and by the exhibitors was that progress had in many cases been too fast. Progress in equipment, which must be carried in the investment accounts, should not proceed so rapidly as to make obsolete relatively new designs by even newer ones before opportunity has been afforded to regain the original investment through the economy represented by performance of the equipment. The manufacturer who presents new designs for identical work before he has been able to recover the cost of engineering development, patterns, jigs, and tools from the recent product before it has been made obsolete by the new, is in a fair way to lose that margin of profit which his ingenuity deserves. From the buyer's point of view, the latest equipment must offer an extra margin of saving beyond normal to absorb not only its own cost but the unpaid-for balance represented in the previous equipment that has become obsolete.

A closer study of equipment offered in the various classes of work shows in each class a distinct progress, but with this progress the balance in production factors between the various departments of work—turning, milling, drilling, cleaning, baths and heat-treatment processes—is not of necessity accurately maintained. There is progress in some departments which represents production volume and operating economy far in advance of other departments. There are also plants where the latest development in one department is required to balance, in integrated production, with the less advanced processes still existing in other departments; where, in fact, the latest refinements and developments are not necessarily required.

However, for those who were in attendance at Cleveland and Detroit, there is no need to argue the success of the exhibits nor the value which was so very evident in every session of the Society's Production Meeting. For those who were not in attendance, something is to be gained by careful study of the papers presented, some of which are printed in full in this issue of THE JOURNAL and others of which are summarized, together with discussion, in the news reports.

CLEVELAND MACHINE-TOOL SESSION

Progress in Grinding Methods and in Motor-Mounting Standardization Discussed

Four papers were presented at the Machine-Tool Session held Tuesday morning, Sept. 20, the respective subjects being External Cylindrical Honing, Developments in Cylinder Grinding, Processes Used in the Manufacture of Abrasive

Units for Cylinder Grinding, and the Application of Electric Motors to Machine-Tools. K. H. Condit, editor of *American Machinist*, was chairman. The paper on the standardization of electric-motor mounting, by R. C. Deale, of the Niles-Bement-Pond Co., New York City, and the paper by L. A. Becker, chief engineer of A. P. Schraner & Co., Cleveland, are printed elsewhere in this issue of THE JOURNAL and may be referred to for full details.

Following the abstract of Mr. Deale's paper, which was read by Chairman Condit because of Mr. Deale's inability to be present, Eugene Bouton opened the discussion by saying in part that the dimension which mainly affects the use of motor equipment is the height from the center of the armature shaft to the base; that is, the bolt holes and the heights referred to are the two dimensions of principal concern. In Mr. Bouton's belief, the motor manufacturers and the machine-tool manufacturers can confer and shortly decide upon what constitutes proper practice in this respect.

A representative of the Westinghouse Electric & Mfg. Co., G. E. Stoltz, outlined the policy that has been followed in the standardization of motors used in the steel mills, mentioned in Mr. Deale's paper, and said also that the motors in which the machine-tool manufacturers are interested are used by every industry. They are of the industrial type, both alternating-current and direct-current motors, and it is recognized by the electric-motor manufacturers that it will be to the advantage of everyone to have dimensions standardized somewhat along the lines indicated in the paper. With regard to the amount of work involved, the statement was made that it is a large undertaking in that, if all the manufacturers become involved, almost a complete redesign may become necessary. In his belief, the best that can be hoped for is to have all manufacturers agree to dimensions and then, as they bring out new lines of motors, the dimensions will be adhered to. He said also that the electrical manufacturers are in favor of this movement and are endeavoring, through committees, to clear this matter up as soon as possible.

Sharpening of Hones

In presenting his paper on External Cylindrical Honing, L. A. Becker said that the company he represents has tried different methods of sharpening the stones. The first attempt was to place the stone in its original condition on the shaft, the stones being ½ in. square and cut to proper length. Further, that there was nothing but a line-contact and, before the contact had worn to become an arc of any considerable size, the results were not satisfactory. The first attempt to correct this defect was to insert a shaft having bearing shoulders of the diameter of the respective bearings of the shafts and to wind these with emery cloth. The shaft was then put into the machine and the stone was brought down to the shaft, which was then revolved; but still the results were unsatisfactory.

A shaft was then constructed which had grinding wheels of the proper size so that each wheel was of the same size as the bearing on which that particular hone was to work. Upon operating this machine, it was found that the grinding stones glazed the wheels and that, in turn, the wheels glazed the stone. In a short time the wheels obtained a polish almost as high as the polish obtained on the crankshaft. Finally, a machine was developed for dressing the stones, using a diamond for cutting, and this method has proved to be satisfactory.

Answering a question as to what percentage of lard-oil and kerosene makes the best combination for honing, Mr. Becker replied that kerosene in itself is very satisfactory and that it would not be necessary to add more than 25 per cent of lard-oil in any case.

In answer to Eugene Bouton's question as to whether other parts of motor-cars, such as the transmission, axles or pistons, had been honed, Mr. Becker said that as an experiment they had honed every part of an engine, such as the cylinders, the crankshaft, the piston-pins, and the pistons themselves, and that the bearings were bored out with a diamond. The engine was then assembled and given a severe block-test, after which it was dismantled and was found to show no appreciable wear on any surface that had been honed. On the block test it showed an improvement of 6 per cent in horsepower developed and a reduction of 25 per cent in frictional horsepower.

Developments in Cylinder Grinding

The paper by M. C. Hutto, of the Hutto Engineering Co., Inc., Detroit, states in part that refinement in production of one mechanical part demands the improvement of all related parts. In the case considered in his paper, the manufacturing of more accurate pistons necessitated the use of better cylinders. It was found that cylinder barrels ground with abrasive wheels rotated at high speed had many disadvantages and that the problem manifestly was to develop new grinding methods which would have the four distinct improvements of greater accuracy, greater speed, better finish, and lower cost. Cylinders lapped with abrasive compound had pleasing finished surfaces and suggested possibilities in that direction. Subsequently, expanding lead laps were designed which were encouraging but still had many drawbacks. The early experiments were important because they revealed the basic principles employed at present. The errors that these experiments showed were studied and corrected.

Improved grinders were then manufactured. Although all these were of crude design, their performance was remarkable at that time. The conditions of actual use in production and service fields necessitated changes suitable to the work, to the equipment and to the operator. Corrective measures resulted from data submitted by the operators.

Acceptance of this new grinding method was slow at first, because it appeared to be radical, but at present it is employed by about 85 per cent of the automobile builders. Grinders recently developed have surpassed in performance the expectations of the designers.

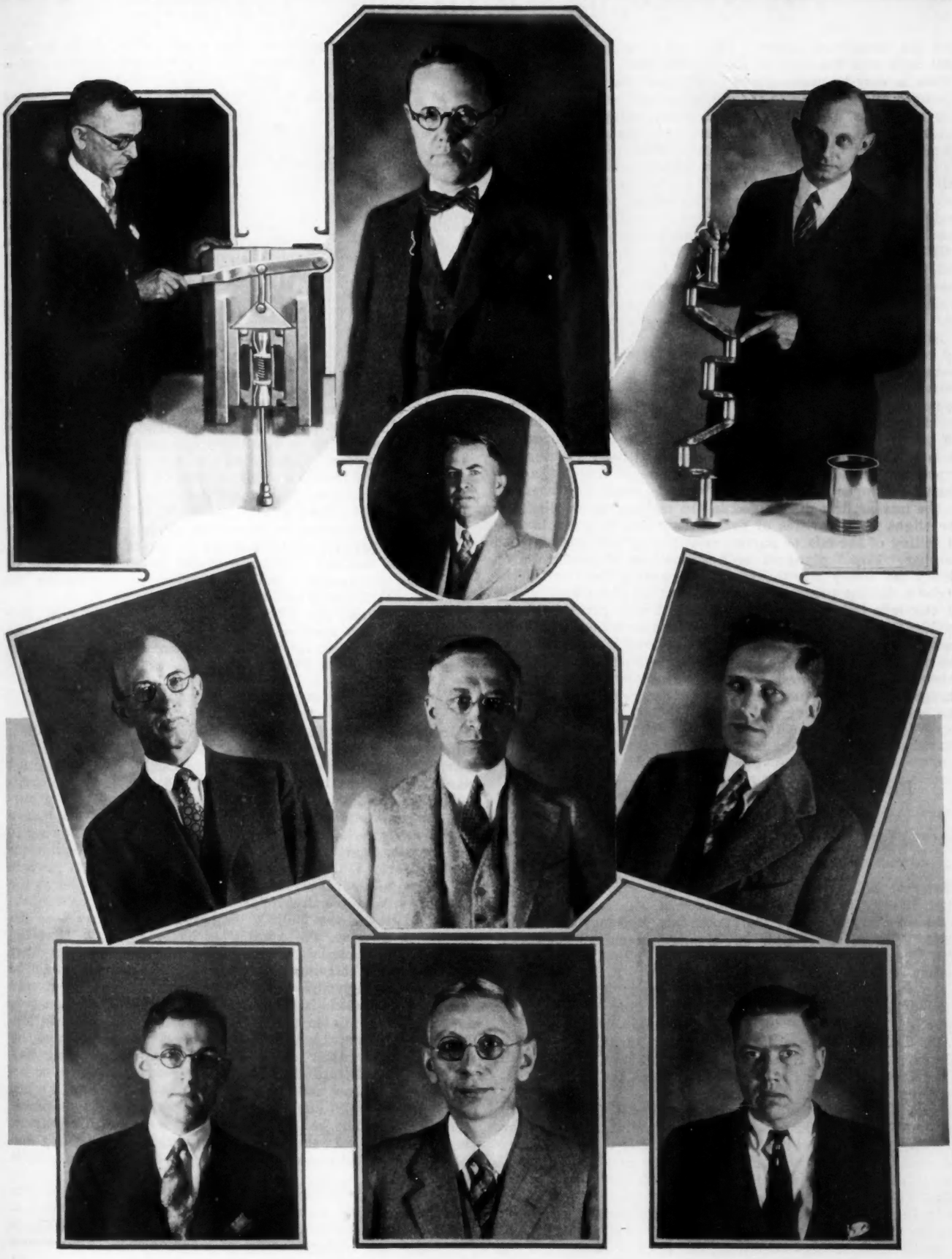
Asked by M. R. Wells, of the Welco Products Co., Cleveland, what the average stone cost is per cylinder in this method of honing, G. C. Paye, who represented Mr. Hutto, replied that this depends on the amount of material that must be removed but that the average cost is 2 to 3 cents for six holes; that is, six grinders set up in multiple control. In response to another question as to what materials other than cast iron have been honed by this process, Mr. Page said that a fair degree of success has been attained in honing steel, but that the honing of bronze is still in the experimental stage.

A question from F. J. Bedford as to whether it has been found necessary to use an up-and-down motion instead of the rotary motion to preserve the stone, brought the reply that to produce an accurate result it is essential to secure proper reciprocation and a proper number of revolutions per minute to get the best results. The speed for best results was said by Mr. Paye not to exceed 300 r.p.m., and the number of reciprocations ranges from 70 to 100, depending upon the nature of the work. He said further that in the automotive field, with cylinder bores ranging from 3 to 3¼ in., it has been found that 240 r.p.m. and 70 reciprocations give the most satisfactory results.

Grinding-Stone Manufacture

Regarding the processes used in making grinding stones, P. H. Walker, ceramic engineer for the Carborundum Co., said in part that in the history of honing or grinding internal-combustion-engine cylinders a great variety of sizes and shapes of abrasive rubs or sticks have been used, and that the shape and method of application to the work determine to an extent the prerequisite characteristics of the abrasive unit as to structure, grit and grade. The speaker's discussion was confined mainly to the requirements for comparatively small sticks approximately 4 to 6 in. long, ¼ to ½ in. wide, and ¼ to ⅜ in. thick.

The first step in the process of manufacture is that of mixing the bond ingredients and the bond with the abrasive



PRINCIPAL ACTORS AT THE MACHINE-TOOL SESSION IN CLEVELAND

K. H. Condit (Upper Center), Who Presided at the Session; M. C. Hutto (Upper Left), Who Discussed Developments in Cylinder Grinding; L. A. Becker (Upper Right), Who Discussed External Honing; P. H. Walker (Right Center), Who Discussed Processes Used in Making Honing Stones; George C. Paye (Circle), Who Presented Mr. Hutto's Paper. Among the Discussers Were A. M. Johnson (Left Center), C. B. LePage (Middle Center), F. W. Stein (Lower Left), G. E. Stoltz (Lower Center), and W. E. Table (Lower Right)

and the temporary binder. The bond is usually mixed in a ball mill and consists of kaolin, feldspar, flint, and such fluxes as may be necessary to form a porcelain of the proper strength and adhesion to the silicon-carbide grain. All bonding materials are subject to close analytical and ceramic control. The silicon carbide must be especially selected as to uniformity of crystal shape and freedom from occluded or any surface impurities. The grit or grits are weighed with the proper portion of clays to give the required grade, and the combination is thoroughly mixed together with a weighed amount of water and temporary binder in mixing machines expressly designed for abrasive mixes. The resulting mix has a very good distribution of clay and grain, but tends to be somewhat lumpy and has to be screened and rescreened to bring it as nearly as possible to a condition in which each crystal has its coating of clay bond and is a unit resting with, but not stuck to, the adjacent crystals.

Since it was impossible to accomplish quantity production by use of multiple molds and automatic presses, it became necessary to form comparatively large slabs by pressing and subsequently cutting up the slabs into sticks by means of templets and a knife. The mix is spread carefully in a mold, approximately 11 in. long and 4 in. wide, and is leveled off perfectly and subsequently pressed by hydraulic pressure. It is in this procedure that the latest and most striking improvement has been made; namely, the addition of a mechanical tamper for applying a definite small unit-pressure to the mix as first distributed in the mold so as to eliminate the slight irregularities of pre-packing due to irregularities in falling of the mix or partial adhesions of one portion with another. Small plungers in a series are allowed to drop slowly but freely into the mix, thus packing the small areas under a definite pressure greater than that of natural falling of the mix but far less than the ultimate pressure to be applied. The application of these plungers leaves a slightly uneven surface, depending on the previous irregularities of the packing. The whole slab is then struck off to a level below that of the lowest impression made by any individual plunger, and a very uniform slab is then ready for pressing and subsequent cutting into sticks.

PRODUCTION COST-ACCOUNTING

Reserve for Depreciation and Budgets for New Equipment Need Intensive Study

Interest in improved methods of cost accounting as applied directly to automotive production was made manifest at the opening session of the Production Meeting held at the Hotel Winton, Cleveland, on Monday morning, Sept. 19. John Younger opened the meeting; but, following his introductory remarks, he relinquished the chair to E. P. Blanchard, of the Bullard Machine Tool Co., Bridgeport, Conn.

Remarking that data on profits accruing from proper usage of machine-tools are especially significant in view of the present tendency of development in the automotive industry, Chairman Blanchard called for the presentation of the first paper, by G. T. Trundle, Jr., of the Trundle Engineering Corporation, Cleveland.

In dealing with the subject of Net Profit from Modern Machine-Tools, Mr. Trundle said in part that the necessity of reducing manufacturing costs to create wider markets and meet competition without a loss has enlarged the importance of keeping a plant well equipped with modern machine-tools. This is a subject that has been neglected, not necessarily because the need of modern machine-tools has not been brought to the attention of management, but because the ready cash has not been available in most cases.

The paper suggests having the necessary funds available by keeping the reserve for depreciation of machine-tools in a liquid condition and the desirability of having some formula suitable for purposes of calculation, particularly one applicable for the replacement of obsolete machine-tools. The author urges that some National organization study the subject of reserve for depreciation and budgets for new equipment.

As a typical example of the possible savings or net profits that can be made by the purchase of a modern machine, an instance was cited in which a part was being made which required two machine-tools. Those used were so old that for many years they had been carried on the books as of "no value," there being in the depreciation account a reserve of $2,000 representing their original cost. The following tabulation gives their performance:

Machine No.	Designated Operation	Performance Time, Hr.
1	*A*	0.033
1	*B*	0.020
2	*C*	0.060
		0.113

A modern machine was available which would perform all three operations in 0.055 hr., making a saving on each piece of 0.058 hr. and requiring but one operator. Sufficient parts were to be made to keep the modern machine busy 9 hr. per day for 280 days per year. At 60 cents per hr. for the operator, the saving is $5.39 per day, or a total saving of $1,509.20 per year. The cost of the new machine was $2,200 and the cost of tools was $500, a total of $2,700. The trade-in value of the two old machines was $350, which, deducted from the cost, $2,700, leaves $2,350. Deducting 20 per cent for depreciation from the saving per year, gives $1,509.20 — $470.00 = $1,039.20, or 44 per cent, as net profit.

Overhead was not considered in the foregoing figures. In this case management saw the wisdom of purchasing the modern machine and had the money available.

In conclusion, Mr. Trundle urged the necessity of constantly auditing machinery and methods so that, when the audit reveals losses, the needed steps can be taken to change these losses into net profits.

Depreciation Reserve Funds Should Be Liquid

In opening the discussion of the paper, Eugene Bouton, supervisor of time study of the Chandler-Cleveland Motors Corporation, commented upon the difficulty the production man has in actually obtaining the funds that have theoretically been held in reserve for depreciation and for the purchase of new equipment. He cited as a supposed example a new factory having $100,000 worth of equipment. Allowing 10 per cent for depreciation, at the end of 5 years the equipment is worth only $50,000, yet the factory is expected to produce the same volume of work of the same quality as when the equipment was worth $100,000. When the production engineer asks for the $50,000 supposedly charged off as depreciation reserve, the auditor is likely to reply that the money is not available, since it is foolish to expect that $50,000 should be lying idle. Although the money should be available through investment that could be converted into the $50,000 needed, it is frequently true that the money is not actually available at the time it is needed. This, in Mr. Bouton's opinion, constitutes a serious condition, and he urged that the matter be studied so that cost accounting may be revised to obviate difficulties of this nature. He also remarked that some machines depreciate more than 10 per cent per year and suggested that the reserve for replacement depreciation be handled in a more scientific way in the future so that management can ascertain the facts and decide what advantages it can secure by the purchase of new equipment.

Guy Hubbard, of the American Society of Mechanical Engineers, said that, at a recent meeting relative to machine-shop practice, which included executives of numerous Eastern companies and representatives of machine-shops, the subject of depreciation reserve was discussed. For some time an effort has been made to inform management of the defects of present methods of accounting for and of spending money. Not only in some instances do the reserve funds disappear in some mysterious way, but in many instances the day of

AT THE OPENING SESSION IN CLEVELAND

George T. Trundle, Jr. (Left), Who Discussed Net Profit from Modern Machine-Tools; L. M. Beatty (Center), Whose Paper on Manufacturing Methods Used in Building the Wright Whirlwind Engine Was Presented by A. R. Fors (Right)

reckoning comes and the entire assets of these companies disappear.

Erik Oberg, editor of *Machinery*, said that he has had the opportunity at various times to learn what is done in automobile plants in determining whether it is profitable to install a new machine and finds that in some plants this is determined in a remarkably accurate and thorough manner.

Asked by Eugene Bouton as to the effectiveness of reports made by a certain firm of engineer accountants, Chairman Blanchard replied that, in the experience of the company he represents, the reports are based on an exact survey of conditions that an unbiased engineer finds in plants in which his company's equipment is used, and that they are very thorough and correct. He also asserted his belief that there is need of recognition of a more or less standardized method of cost calculation, especially for comparative purposes. He believes that production engineers should devise a standardized formula, so that, with the facts available, they can apply it and thus avoid arguments.

A comparison between abandoned farms and reserve for depreciation was made by John Younger, who said that many of the farms were abandoned because the farmers did not "plow-in" some of their profits, and that the same reasoning applies to depreciation reserve.

The second paper was by Lee M. Beatty describing the production methods used in building the Wright Whirlwind aircraft engine. In Mr. Beatty's absence, it was read by A. R. Fors, of the Continental Motors Corporation. Extraordinary vigilance at every stage of production of every part of the manufacture contributes to the success of the engine, repeated tests and inspections being made of the parts of the engine in process and also of the engine after it is assembled. The paper is printed in full in this issue of THE JOURNAL beginning on p. 361.

PRODUCTION-UNIT INTEGRATION

New Production Era Brought About by Broader Vision of Production Engineer

The present new era of production has been made possible by the broader vision of the production engineer, who is now an established factor in industry because of the demand for reduced production costs, according to E. P. Blanchard, advertising manager and assistant sales manager for the Bullard Machine Co., Bridgeport, Conn., who presented his paper on Integrated Production at the evening session of the Production Meeting held in Cleveland on Sept. 19. A. H. Frauenthal, engineering department of the Studebaker Corporation of America, South Bend, Ind., in charge of factory investigation, was chairman.

According to Mr. Blanchard, to the two production principles of the division of labor and the transfer of skill to machinery is added a third principle, which is integrated production, or the combining of work units, so that a number of identical or similar operations are performed by multiple tools simultaneously in a way to comprise a complete process or method performed with maximum efficiency in the shortest possible time. The paper is printed in full in this issue of THE JOURNAL beginning on p. 375.

Following the presentation of the paper, J. D. Ceader, manufacturing engineer for the General Electric Co., cited the experience of his company in line with "simultation," which, according to Mr. Blanchard, is a mathematical factor and refers to the multiplication of tools in simultaneous operation. Mr. Ceader said that in 1921 his company made 80,000,000 miniature lamps, perhaps half of them being for the automobile trade. At that time these were made under departmental methods in 10 factories employing about 4500 operators throughout the Country. During the last 4 to 6 years, the equipment development of the business has progressed to simultaneous operations in which multiple-head equipment is used. This reduced the number of unit factories from 10 to 3, and has increased the production in the 3 unit factories from 80,000,000 lamps made in 1921 in 10 factories to 130,000,000 made in 3 factories, which represents a reduction in direct-labor operators from 4500 to 1500 in 6 years.

Production men are likely to forget, said John Younger, that there are two sides to production. One is the side that is occupied with machining; the other is concerned with the economics of machining and with the decrease of labor costs, so that the importance of a knowledge of economics is strongly emphasized. In Mr. Younger's opinion, economics should be studied more intensively by production men.

Remarks were made by G. A. Schreiber, consulting engineer, Detroit, to the effect that in Italy, France and England the problem of production rested with the designer up to about 1926, at which time there began to be good cooperation between the designing engineers, the production engineers and the builders of machine-tools. This combination has brought about better motor-cars and better units.

Eugene Bouton, referring to Mr. Blanchard's mention of the division of the cuts by the simultaneous use of numerous tools, the work of which would balance as nearly as possible, pointed out the possibility that where a group of say five or six machines is used and the schedules are suddenly reduced, any one of the machines may be able to produce more than is called for by the reduced schedule. In this case, he said that he has known instances where machines were slowed down to give the amount of production scheduled and the number of operators was reduced from five to perhaps one, two, or three. He mentioned this, he said, as an instance of how machine-tools can be slowed down rather than speeded up to secure economical production. In reply, Mr. Blanchard said that, under such conditions, it is better to pay the carrying charges on the machinery and reduce the labor cost.

Norman G. Shidle, editor of *Automotive Industries*, asked why the peak of efficiency mentioned by Mr. Blanchard is set somewhat above the expected quantity of production, in view of the fact that in the automotive industry the quantity of production very frequently is below that of the original estimate. Mr. Blanchard replied by saying that there is an added increment in economy in setting up the equipment for a quantity greater than that for which the production engineer plans because, in investing the money in machinery, it is cheaper in the end in the cost per piece than to spend it for hand labor or to accept a lesser degree of refinement and to put more work into the cost of producing the piece.

It was stated by Ernest F. DuBrul, general manager of the National Machine Tool Builders' Association, that proper application of the basic principles such as those indicated by Mr. Blanchard is required before satisfactory progress in any line of work can be attained and that, as regards integrated production, the application of its principles will result in considerable benefit.

Illustrated Talk on Power and Prosperity

Following the conclusion of the technical session an instructive and entertaining lecture was given by Charles M. Ripley, electrical engineer for the General Electric Co., who presented groups of pictures taken in Europe and Asia during his recent travels there. The first group was illustrative of his flights over the airways of six European countries, the distance traveled being approximately 2500 miles. Numerous types of airplane were shown and running comment thereon was made by the speaker. The second group of pictures had to do with peasant life in Europe and Asia, comparisons being made with somewhat similar pictures taken in the United States. These showed the startling improvement that can be attained in countries where the power resources and manufacturing capacity have been utilized to maximum advantage. In the third group, Mr. Ripley used his illustrations as an aid to explaining why it is that the standard of working conditions and the standard of living in the United States are so far different from those in any other country in the world.

In a diagram illustrative of the machinery by which such improved conditions become possible, the speaker showed that power in increasing quantity is the essential prime factor. With unlimited power and with the aid of electricity, power becomes cheaper and the people make more use of it. As more power is used a larger output of all kinds of commodities is achieved. The result is, according to Mr. Ripley, that it is possible to give higher pay to the workers and also to lower the selling price of the product. Consequently, because of higher pay, the people have more dollars to spend. On account of the lower prices, each dollar will buy more of any given commodity and general prosperity prevails; in other words, power has made American standards what they are and has increased the dignity of labor.

The rapid-fire epigrammatic style of the speaker and his witty comment on the scenes flashed upon the screen brought forth frequent applause and laughter, the audience seeming to feel that in a measure its members had been participating in an actual trip abroad.

ULTRA-MODERN MACHINE-TOOLS

Enormous and Well-Staged Exhibition at Cleveland Eclipses Previous Shows

Progress made in the last year in the design and construction of machine-tools for all purposes was evident everywhere at the huge showing in the Auditorium Annex, Cleveland, during the week beginning Sept. 19. Many new machines were exhibited, some of which were the only ones of the kind yet built; and numerous familiar types of machine were seen to be equipped with radical improvements. That the show compelled intensive interest and study by representatives of the mechanical arts was proved by the fact that so many of the engineers who were attending the 1927 S.A.E. Production Meeting spent so much of their time viewing the exhibits, as well as by the throngs of representatives of other industries who kept the long aisles crowded. Effective overhead decorations, of colored bunting, flags and emblems, created an atmosphere similar to that of a fair, and the great care that evidently had been exercised in staging the individual exhibits to greatest advantage heightened the general attractiveness of the event considerably.

Some of the tendencies noted as to machines directly applicable to automotive production were toward new or improved grinders of various types for special purposes; honing and lapping machines; gear-cutting, gear-grinding and gear-burnishing machines; equipment for the static and dynamic balancing of engine and other parts; automatic gear-testing apparatus and other testing devices; and multiple-operation machines of various kinds. A distinct trend toward refinement of the finished product through improvement of the tools used and toward the designing, when needed, of new tools and new machines was evidenced, in addition to the many examples of improvements that have increased the capacity of various types of machine-tool and have thus speeded up production.

One multiple-spindle machine for lapping or honing all the cylinder bores in a four, six or eight-cylinder engine-block simultaneously was noted in which, by shifting a lever, the laps are started rotating and are brought down to the working position. They then reciprocate a predetermined number of strokes and are returned to the loading position and stopped automatically. The reciprocations per cycle are controlled by an index plate, which can be changed to give any desired number of reciprocations. The stroke is adjustable from 4 to 6½ in., and the heads can be adjusted to different centers. A pump keeps a steady flow of the cutting compound on the lapping tools, and the compound is thoroughly cleaned of grit and dirt before it is again pumped on the lapping tool.

Gear-Finishing Machines

At least three companies exhibited gear-finishing machines. The operation of one of these was said to differ from other rolling or burnishing operations used to improve the running qualities of gears in that it corrects errors in the contour and spacing of the gear teeth, at the same time creating a perfectly smooth surface. The work spindle has a reciprocating motion which feeds the gear that is being finished forward and back across the face of the tool gears. A slight amount of stock is left on the tooth in the rough-hobbing operation, and the tool gears, exerting a tremendous pressure on a minute portion of the face of the tooth, helically displace the small amount of stock left for finishing and thus produce accurate tooth-form and spacing. The operation requires one pass forward and back across the face, the direction of rotation being automatically reversed as the feed reverses, and, at the completion of the return stroke, the machine stops. Automobile transmission gears of approximately ¾-in. face are finished accurately in an average time of 20 sec. each, regardless of the number of teeth. The finishing is done before the hardening operation. If small errors due to heat-treating or hardening develop, they can be removed, if desired, by grinding the gear.

Another make of gear-finishing machine provides means for running the green gear between three hardened master-gears of suitable design under pressure. Advocates of the burnishing method of finishing gears claim that it improves the contours of the teeth, rolls out any small nicks or defects, produces a smooth surface, and irons down or compacts the material so that a dense surface is produced which increases the life of the gear. The machine observed is entirely automatic. After placing the green gear in position between the master gears, the operator pushes the lever down, thus bringing the gear to be burnished into engagement with the driving gear on the spindle. After the machine starts in the forward direction and makes a predetermined number of revolutions, the spindle reverses and makes the same number of revolutions in the opposite direction; it stops automatically upon completion of the cycle. The design aims to eliminate the personal equation in securing constant pressure, to provide a definite time of burnishing, to reverse the operations without removing the gear, to provide quick loading and unloading facilities, and to incorporate mechanical refinements such as ball bearings and automatic oiling.

Static and Dynamic Balancing

A static balancing-machine shown has features designed to give great accuracy and provide also for high routine production. It affords means for balancing flywheels, clutches, automobile wheels, and wheel parts. The operation of the machine is simple, consisting of bringing the frame to level, turning the piece 90 deg. and again bringing the frame to level, drilling the required amount of material, and checking the corrections. It was stated that on one of these machines

Celebrities at the Monday Evening Session at Cleveland

E. P. Blanchard (Upper Center), of the Bullard Machine Tool Co., Who Discussed Integrated Production; A. H. Frauenthal (Upper Left), of the Studebaker Corporation of America, Who Presided at the Session; E. F. DuBruhl (Upper Right), General Manager of the National Machine Tool Builders' Association; Norman G. Shidle (Lower Left), Editor, *Automotive Industries;* G. A. Schreiber (Lower Center), of Detroit; and Joseph D. Ceader (Lower Right), of the General Electric Co.

one operator has been producing 25 to 30 completely balanced, corrected and checked wheels in 1 hr. The machine is sensitive to an unbalance of 0.2 oz-in. By a simple process it gives a direct measurement of the amount and location of the required correction. A summary of the advantageous features of a dynamic balancing-machine exhibited includes claims for a high degree of accuracy in the parts balanced, complete corrections, uniform product, and that the time required to secure an accurate balance is short. These, with other features of advantage, make it possible to secure a high rate of production and to put balancing operations into the production line because the machine produces at a fixed rate irrespective of the amount of error or of its location.

JOHN YOUNGER
Chairman, Production Meeting Committee

GEAR-INSPECTION DEVICES

Relative to gear inspection, one machine for this purpose that was shown is automatic in operation and provides means for mechanically inspecting gear teeth and recording the errors so that the essential characteristics of the gear can be checked. The machine includes two studs, one fixed and the other movable. The movable stud carries the master gear, of known properties; the fixed stud carries the gear to be tested. The machine is based on the principle of changes in center distances being effected by errors in profile, tooth spacing or eccentricity. Therefore, these inaccuracies impart a movement to the movable stud. In turn, the movable stud transmits movement to the charting pen that traces a record on ruled paper which is unwound from a roll and advances at a fixed rate past the point of the charting pen. Eccentricity of the gear being tested causes the recorded line on the chart to depart from and to return to the datum line in one revolution of the gear being inspected, reaching the maximum deviation when half way around the gear. The device charts the amount of eccentricity magnified 200 times, and thus enables the inspector to check up this error to very close limits. The other defects of the gear being tested are also indicated by the chart, such as thick and thin teeth, variations in tooth-to-tooth spacing, and the like.

One of the testing devices for measuring slight variations in tooth curves and tooth spacing makes use of the principle employed in developing the involute curve for any gear tooth. When a straight-edge is placed tangent to a circle, and is rolled upon the circle, any point in the tangent line will trace the involute curve of that circle. The circle upon which the straight-edge is rolled is called the base circle, and all involute curves having the same base circle must be identical. The only differences between various involute curves must be differences in base-circle diameter; therefore, the testing machine has mounted upon it the base circle with provision for holding the straight-edge in contact with the base circle at sufficient pressure to assure that it will roll upon the base circle without slippage. By these and other means provided, all gear teeth can be compared with the true involute curve and it is thus possible to establish a standard of accuracy and to determine whether any gear out of regular production is accurate within the specified limit.

Another make of gear-testing instrument for inspecting gear-tooth spacing is equipped with an optimeter for taking readings from a graduated scale. The maximum size of work that can be tested is 24 in. in diameter and 1-in. circular pitch. The testing unit has a single arm on which is mounted the tube for carrying the optimeter and the contact fingers. Both fingers are clamped on the tube so that they bear against the same side of adjacent teeth. One finger is pivoted in the center and acts to move the graduated scale within the tube. When observed through the eye-piece of the optimeter, the graduations appear to be 1/16 in. but they indicate spacing variations in units of 0.00005 in. In turning the gear for checking successive teeth, a handle on the end of the swinging arm is given a quarter turn which acts to lift the fingers above the gear teeth, thus permitting the gear to be turned on its center far enough to let the fingers into the adjacent tooth spaces.

An example of a gear-tooth grinder of the pure generating type that was exhibited has an action similar to that of rolling a gear along an imaginary rack, with the grinding wheel acting as a tooth of a rack. The gear is mounted at a suitable loading height, the dished grinding wheel, 30 in. in diameter, being below the gear and being capable of reversal and swiveling on either side of the center up to an angle of 25 deg. The work spindle carries the generating mechanism at the rear, the indexing is powered from a drum cam, and a mechanism is provided that stops the carriage, the wheel or both, as desired. A water guard covers the wheel and the work, and the machine is self-contained. A cheek-facing and pin-roughing lathe was exhibited that turns all cheeks of a crankshaft and rough-turns the pins in one operation.

An interesting surfacing machine for roughing and finishing one or more flat or irregular surfaces in one operation was observed. Machining is done with flat-bed cutters or broaches and the finish is said to be equal, or superior, to planed or milled surfaces, a further claim being that the use of this type of cutter for machining has several advantages. One is that the lower teeth are always used for roughing and the upper teeth are reserved for the lighter finishing cuts. The teeth are all supported directly behind their cutting edge and not at a distance as in the case of milling teeth which are supported at some distance by the milling-cutter arbor. The cutter operates at slow speed. On one job of machining steering-knuckles, the travel of the cutter or broach is about 9 ft. per min., which is only 10 per cent of the possible cutting capacity of the broach. The machine is semi-automatic in operation, the operator merely loading and unloading the fixtures with the work and tripping a lever to release the fixture. Several examples were cited of work handled by this machine. One was the finishing of both sides of two bosses, four surfaces in all, of an automobile front steering-spindle connecting-rod yoke. The finishing of the two flat surfaces that receive the dust cover for the front-wheel brake on automobile steering-knuckles was another example in which production had been increased greatly. It was claimed that in another shop the machine replaced six men and six machines; in still another shop, it was said to have increased production 400 per cent.

TURNING AND THREADING MACHINES

A heavy-duty automatic crankshaft lathe having a center driving-head and providing an advanced machining method for crankshafts, so that the stub and the flange-end bearings of a crankshaft can be machined simultaneously, was exhibited and demonstrated by one company. The machine has two front and two rear facing slides which feed toward the center of the machine. Both stub and flange-end bearings are formed to rough grinding-size in a single operation simultaneously, combining operations heretofore handled on separate machines. The crankshaft is located in a center driving-head on a previously machined center-bearing and is sup-

ported by adjustable centers. The driving fixture revolves in two large-diameter replaceable bronze-ring bearings. An overhead air-operated loading-device reduces to the minimum the time and effort required to load and to unload the machine. Since the machine is entirely automatic, the sole function of the operator is to load and unload and to engage the feed lever.

An interesting new automatic multiple-spindle machine of the continuous-unit type for the machining of work held between centers in a vertical position was on exhibition which has six work-spindles in a carrier and six tool-heads mounted on a tool column. The respective tool heads always remain in direct relation to each other and form six individual units which, in operation, are rotated around the central column. One complete cycle is required for the chucking, machining and unloading of a single piece, but six units operating simultaneously produce six pieces during the cycle time.

Another machine-tool shown by the foregoing exhibitor embodies new ideas in design and in its application to production. It is an automatic vertical turret lathe primarily intended for that low cost in production for small and intermediate quantities which can be surpassed only in larger quantities by multiple-spindle models for the same purpose.

An interesting automatic forming and threading machine for manufacturing bolts that was observed has a turret on an axis inclined about 30 deg. from the vertical. An automatic hopper-feed loads the bolt blanks in a slide, from which they are transferred by an arm which swings through an arc of 180 deg. to the loading and unloading stations of the turret, where they stand point up. At the first working station the bolt is trimmed to length and the end is formed by a rotating tool. A rotating die at the second working-station threads the work, and the threaded bolt is ejected at the unloading station before a new blank takes its place. On ½ x 2-in. bolts, the capacity is 900 bolts per hr.

Numerous devices which represented improvements were observed in line with hydraulic operation, especially in connection with grinding. Other machines for special purposes also, in many instances, were hydraulically operated.

STAG CARNIVAL ATTENDED BY 300

Brilliant Event Staged in Cleveland on Second Evening of Production Meeting

The Rainbow Room of the Hotel Winton in Cleveland was the scene of festivity on the evening of Tuesday, Sept. 20, when 300 automotive production engineers assembled there for the Stag Carnival, the only social function arranged in connection with the 1927 Production Meeting of the Society and the Machine-Tool Builders' Exposition.

Many of the men attending were out-of-towners who consequently had no difficulty in getting a free evening for a stag affair. Many others, however, registered as residents of Cleveland, and what they told their wives about their activities on that evening remains a family secret. One, it was learned, informed his wife that he was going to attend an Inspection Session; perhaps the same excuse served others, for it was far from inappropriate. The Carnival was one occasion when all present, whatever their various lines of work might be, did a great, not to say staggering, amount of inspecting.

First they inspected the Rainbow Room itself and its decorations, which included a large S.A.E. banner. Bright-hued flowers upon each table pleased the eye immediately, and the more utilitarian appointments on the table promised delights of a different kind. Continued inspection showed that the room was provided with a stage; this discovery, with its implication of still further duties for the 300 hard-working inspectors, seemed not to daunt them at all. If anything, it increased their interest. Mere anticipation of a strenuous

A View of the Machine-Tool Builders' Exposition at Cleveland

evening of visual inspection seemed to give them intense pleasure, and later happenings indicated that the anticipation was happily surpassed by the realization.

After viewing the room, greeting their friends and cogitating upon the labors that awaited their palates and their eyes, the industrious inspectors were initiated into their duties by the arrival of waiters, who placed before them delectable viands upon which judgment had to be passed. In the process, the scrutinized product was entirely consumed, that is, tested to destruction, and a unanimous verdict pronounced the dinner excellent.

The Pleasures Were Varied

Excessive concentration upon a task has been known to produce unsatisfactory results. It may have been for this reason that the management of the Carnival insisted that the faithful inspectors be diverted periodically during the work of passing judgment upon the dainties that the waiters had set before them. An orchestra of sailor lads furnished a tuneful accompaniment to the meal, and some songs by two pretty girls were enthusiastically applauded. Then the real work of the evening began, and the indefatigable toilers applied themselves diligently to a close and intensive study of methods and processes connected with various types of body design, as songs and dances, dances and songs, were presented for their edification and delectation.

What! No Speeches?

Formal talks were not included in the program. No speeches, therefore, were made except certain remarks of a laudatory, stimulating or encouraging nature that were addressed to the performers by several exuberant and irrepressible spirits among the inspectors. The absence of the formal speeches was not noticeably regretted, and the utterance of the ex tempore remarks mentioned merely added to the liveliness of the occasion.

To say that "a good time was had by all" would be true but trite. The expression is therefore barred from this account and is hereby deleted, solely on account of its triteness; its truth is unimpeachable.

To Leo L. Williams a high degree of credit should be accorded, as the Stag Carnival was under his able management and its success is due to his untiring and well-directed efforts.

PRODUCTION COMMITTEE MEETING

Future Activities of Production Advisory Committee Discussed at Cleveland

Discussion at the dinner meeting of the Production Advisory Committee held at the Hotel Winton, Cleveland, Sept. 19, centered on what the activities of the Committee should be in the near future. The following members of the Committee were present: Eugene Bouton, chairman, Chandler-Cleveland Motors Corporation; Fred H. Colvin, *American Machinist;* A. R. Fors, Continental Motors Corporation; W. W. Norton, Autocar Co.; and John Younger, *Automotive Abstracts.* Others present were: E. P. Blanchard, Bullard Machine Tool Co.; J. Dana, General Electric Co.; A. H. Frauenthal, Studebaker Corporation of America; and S. N. Sawyer, Cleveland Tractor Co. The Society's staff was represented by R. S. Burnett, F. H. Hazard and C. E. Heywood.

The desirability of inducing the production-engineer members to take active part in the Sections' work was expressed and means for making the activities of the Sections attractive to them were suggested. The point was made by Mr. Burnett that men actually engaged in production work are so tied down by their activities that they find it difficult to attend the meetings and to write papers. However, the possibility of writing special letters to the Chairmen of the Sections and attempting to outline the Section Meetings programs in advance, which would include one or perhaps two special production-engineering meetings in the course of a year, was suggested. It was stated by Mr. Burnett that the Sections Chairmen already had been communicated with in regard to the matter, and it was suggested by Mr. Younger that President J. H. Hunt be requested to follow this up by personally writing to the Sections Chairmen urging activity in the line of attracting production engineers. Mr. Colvin mentioned that, in case of soliciting papers from production engineers, some definite topic should be assigned to them rather than to ask them what they have that is new and request that they write it up.

The matter of holding two Production Meetings per year per Section was said by Mr. Burnett to depend considerably on the character of the industries in the Section territories, which varies in different localities. In the opinion of Mr. Blanchard, a Production Meeting can be held by a Section successfully even though the membership of the Section may be composed of men not directly interested in production.

Cost-Accounting Activities Desirable

It seemed to be the consensus of opinion of those present that production cost-accounting is an important economic phase of production engineering and constitutes an activity that might well be taken up by the Committee. Details of how this might best be done were discussed but no decision was reached. Mr. Burnett suggested that a Subcommittee could be appointed to send out a letter somewhat in the form of a questionnaire for data concerning the problem and how it could be handled and summarized.

The fact that the production engineer in a plant is not in a position to deal with the economics of costs was mentioned, and Mr. Norton called attention to the difficulty of getting management to go into the subject of cost accounting as relating to production in the plant. Mr. Bouton stated that management must be made in some way to become interested in production engineering so that the production engineer can be better informed and can work to better advantage. Mr. Younger called attention to what a proper definition of the word "appraisal" comprises. He suggested the desirability of broadcasting an appeal to managers to take a production appraisal yearly.

In Mr. Blanchard's opinion, no objections by accountants' representatives would be developed by activities of the Committee in line with production cost-accounting, since the analyzing of costs for machine-tools and the necessary equipment is on a different basis from that of ordinary business accounting. In his opinion, appraisal should be set up from the production engineer's viewpoint. He stated further that an outline should be obtained from a few production engineers regarding the relative importance of different phases of their work, such as overhead, tooling, maintenance, and upkeep, and that they should be asked to say which one of these they consider is most important. He mentioned that many production men do not know what their problem in this connection is and urged that they give it more extensive study.

The meeting was adjourned without the adoption of a definite program, but it was understood that the members of the Committee and the Society's office would continue to cooperate toward this end.

Fire Hazards and Steels Featured in Detroit

After the Stag Carnival Tuesday evening in Cleveland, the Production Meeting contingent of the Society moved on by boat to Detroit and convened in the banquet room of the Hotel Statler for the Steel Session at 2 p. m. Wednesday. John Younger, Chairman of the Production Meeting Subcommittee, introduced F. P. Gilligan as chairman of the session, and O. A. Knight, Detroit district manager of the Norton Co., Worcester, Mass., presented the first paper, on 1927 Grinding Practice in the Automotive Field.

Mr. Knight restricted his subject to external grinding of cams and cylindrical surfaces, which was illustrated with many lantern slides of the latest machines produced for the purpose, of the work they perform and of the control features. The grinding-machine is said to be the only machine-tool capable of reproducing the degree of accuracy that is used in its building and to be an important factor in the great reduction in the number of man-hours of labor entering into the cost of each car.

With the latest camshaft grinding-machines the operator merely moves the table to bring the cams successively opposite the grinding wheel. An air-operated shifting mechanism shifts the master cams automatically. An automatic reciprocating motion is given to the grinding wheel, so the operator is not obliged to reciprocate the table during the cutting. These improvements, said Mr. Knight, have increased the output of the machine 50 to 65 per cent.

Grinding Two Surfaces at Once

Differential side-gears have formerly been ground on the hub and the back of the gear flange in two separate operations. They now are being ground in one operation with a special machine carrying a mitre-faced wheel on an angular slide, one side of the mitre grinding the hub and the other side grinding the back. An air-operated chuck speeds up the operation. There is also a machine with a swiveling head for grinding the spherical back of differential pinions.

Double-wheel grinding is being used successfully in a number of instances. Sometimes both wheels are of the same diameter, as when grinding two crankshaft-bearings simultaneously, and sometimes they are dressed to different diameters, as when finishing the bearing surfaces on a steering-knuckle.

Starting-motor armatures now are being ground on the laminations. This work is done dry, and an exhaust-wheel guard removes the dust to prevent injury to both operator and machine.

Wheels as wide as 20 in. are used for grinding the outside diameter of a row of bearing races, and wheels of large diameter are used for crankpin bearings. The problem of balancing is more acute with such large wheels, and some of them are being mounted on sleeves fitted with weights that can be adjusted to correct any unbalance that may develop as the wheels wear down. Balance is especially important when a very smooth or "reflective" finish is required.

Automatic Grinding-Machines

Development of the automatic features of centerless grinding has continued, said Mr. Knight, and an automatic machine has been developed for grinding work on centers, using a hopper feed for the work and compressed air for operating the loading and other operations that would be done by the operator in a hand-operated machine. Bolts, valve-guide bushings, piston-pins, and pistons are among the automotive parts that can be ground on this machine.

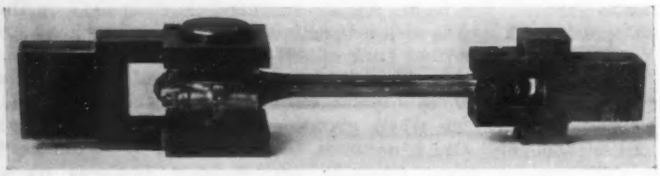
The relief on the side of cast-iron pistons, near the piston-

Speakers at the Detroit Steel Session

O. A. Knight (Left), Who Discussed Recent Developments in Grinding; E. J. Janitzky (Center), Who Discussed the Need for Developing Frequency Curves as a Basis for the New S.A.E. Physical-Property Charts; and J. M. Watson (Right), Who Discussed the Relationship of the Metallurgical Department to Production

pin hole, is being ground by machines with cam-controlled slides, just as engine camshafts are ground.

In conclusion, Mr. Knight said that the automotive industry has become an important source of business for machine-tool manufacturers and has encouraged the development of better machines to produce more accurate work in shorter time and with a reduction of manual labor.



METHOD OF TESTING CONNECTING-RODS
The Complete Connecting-Rod Can Be Tested for Tension, Compression or Torsion in a Standard Testing-Machine, Using the Special Jaws Shown

In answer to a question by Mr. Younger, the speaker stated that the greatest demand in the automotive industry is for a better finish. Turning, grinding and lapping are separate operations, the last producing a more velvety finish. Some makers of camshafts are now buffing the cam surfaces. In the future these surfaces may be honed.

METALLURGICAL SPECIMENS AND TEST METHODS SHOWN

A paper on The Relation of Metallurgy to Production was presented by J. M. Watson, metallurgical engineer of the Hupp Motor Car Corporation and chairman of the Iron and Steel Division of the S.A.E. Standards Committee, who illustrated his paper by showing a connecting-rod assembly with mounting attachments such as he uses for the assembly test mentioned in the paper, printed on p. 370 of this issue of THE JOURNAL. A photograph of this exhibit is shown in the accompanying illustration. He also exhibited a group of bars of various materials in the form of tensile-test specimens mounted on a board. All of these specimens were turned to diameters calculated to provide a certain strength. The samples are of chromium steel, crankshaft stock, screw steel, malleable iron, and grey cast iron, and the different diameters required to develop the same strength in the various materials give a visual evidence of the relative strength of the materials. This board has been used by Mr. Watson in his talks to salesmen to assist them to realize the advantages of using high-grade materials in the manufacture of a car.

ALLOY-STEEL PHYSICAL-PROPERTY CHARTS

The last paper at the session, Correlating Test-Data on Heat-Treated Chromium-Vanadium Steels, was presented by E. J. Janitzky, metallurgical engineer of the Illinois Steel Co., who outlined the work performed and the method of procedure followed in correlating test results on specimens of heat-treated S.A.E. chromium-vanadium steel 6130 as a basis for revision of the physical-property charts for certain automotive steels.

Revision of the charts was proposed by the Iron and Steel Division of the Standards Committee of the Society, and a subcommittee, of which Mr. Janitzky is a member, was appointed to carry on the preliminary work of revision. Test-specimens, to be drawn at three different temperatures after quenching, were prepared by four steel manufacturers. These were distributed among 30 cooperating laboratories, which made a series of about 115 tests of the specimens, including complete chemical analysis, tensile-strength, and Brinell, scleroscope and Rockwell hardness tests.

Results of the tests were shown by the author in frequency or probability curves, rather than in straight-line curves of averages alone, since the latter are regarded as an unsatisfactory method of expressing the results of such an investigation because of the variables. It was necessary to express the results so as to indicate a range, limited by minimum and maximum values, within which users of the charts might be expected to obtain satisfactory results.

GREAT NUMBER OF DATA NEEDED

Mr. Janitzky's paper was the subject of considerable discussion. Some of the members thought that the mathematical work involved in determining the values must be very great, but Mr. Janitzky explained that it is a simple matter once the vast amount of data have been assembled. Mr. Younger stated that the frequency method of obtaining an average is very useful in a great variety of work.

Chairman Gilligan pointed out as essential that this is a proposed method for improving the physical-property curves for S.A.E. Steels. Adequate data that now are in the files of various metallurgists must be made available for the work of the Committee. J. H. Hunt, president of the Society, asked how the designer would use the double-line chart; if he would not need to use the minimum values for strength or else add enough to his factor of safety to allow for that. The chairman explained that the leading manufacturers have more exact data on steels they are using, and that an engineer who has not this additional information will know that he can use minimum figures or secure more specific information on the steel he is considering. It is one step farther in educating the steel user.

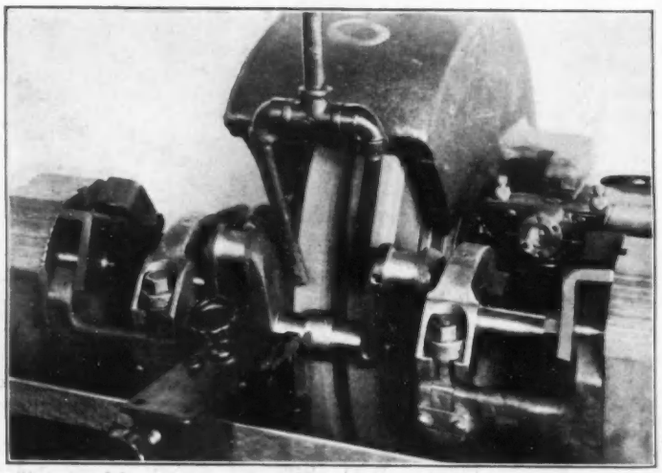
It was brought out that a great amount of work would be required to secure data and prepare the proposed form of curves for all S.A.E. Steels, and that the Iron and Steel Division would like to know, before undertaking it, if the results would be valuable enough to the designer to justify the work. Various methods were suggested for getting information on this point, as by letters, by personal calls, and by further discussion in a general meeting of the Society.

FIRE RISKS AND SELLING STUDIED

Spraying of Inflammable Finishes and Selling Ability of Engineers Featured

Fire Hazards Incidental to the Spraying of Inflammable Finishes, written by H. L. Miner and read by P. V. Tilden, both of E. I. duPont de Nemours & Co., Wilmington, Del., was the title of the first paper presented at the session of the Production Meeting held in Detroit, on Wednesday evening, Sept. 21. John Younger was chairman.

The paper states in part that spraying of finishing materials with compressed air began about 1890, was increased greatly during the World War, and has become a necessity with quick-drying finishes of the pyroxylin type; so, about three-quarters of the finishing materials today are applied by that method. The fire hazards have long been recognized



DOUBLE-HEAD GRINDING-MACHINE FOR GRINDING 2 AND 3-IN. CRANKPINS ON A CRANKSHAFT, DESCRIBED BY O. A. KNIGHT

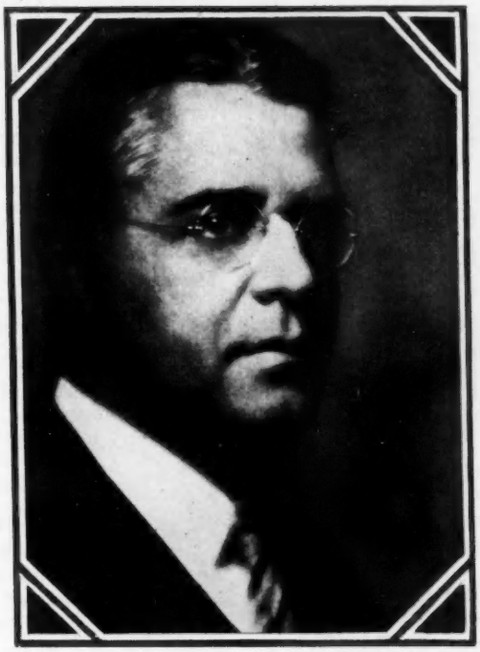
and guarded against, but study of recent serious fires has shown how greater safety can be secured. The danger is due mainly to the spraying method rather than to the difference between oil paints and pyroxylin finishes, but it is notable that the lowest temperature at which combustion of a liquid will occur bears no relation to the flash point.

Variation in the temperature of ignition has led to the discovery that various materials exert catalytic influence. In particular, copper will ignite spirits of turpentine at 285 deg. fahr., which is lower than the charring temperature of wood or paper, while steel must be heated to 425 and zinc to 580 deg. fahr. to have the same effect.

No vapor or dust that is diluted below the low limit of its explosive range can cause a fire hazard. Adequate ventilation will provide for such dilution and remove the combustible material. Of course, other fire hazards must be eliminated and good housekeeping maintained, including the removal of any accumulation of slow-drying finishes or dust from quick-drying finishes. Spray booths or tunnels should have exhaust-fan equipment to move the air at a velocity of not less than 125 ft. per min. If spraying is done in an open room, the air should be completely changed every 3 min.

Cleaning the interior of the spray booth is made easier by coating it with grease or non-oxidizing oil. It can be covered with heavy manila paper that is stripped off, removed from the building and immediately burned, or the greased surface can be cleaned with a blast of wet steam while the ventilating system is in operation. Employes should not be allowed to enter ducts connected to pyroxylin finishing-equipment until the ducts have been freed from inflammable vapors and wet down for their entire length.

Two tables were shown during the reading of the paper. One gave the flash point, apparent ignition-temperature and explosive-mixture range of various liquids used in spraying, and the other gave temperatures of copper, steel, brass, aluminum, and zinc that will cause ignition of explosive mixtures of various spraying materials.



A. R. Glancy

Factory Men Discuss Paper

Several men responsible for the safe condition in the paint-spraying departments of various automobile factories took part in the discussion. O. C. Ward, of the Hudson Motor Car Co., Detroit, said that the stacks at that plant are washed out and the booths steamed out each evening, and that the sprinkler heads are cleaned. The booths are coated with a greasy material. The pyroxylin is cleaned off the pipes and steam coils once each month. Earl Seger, of the same factory, brought up the problem of workmen who begin spraying as the car approaches the booth and the danger of this practice was emphasized.

A new spraying room is under construction at the Chrysler plant, according to H. S. McClellan, of that plant, and they are wondering if there is danger from static electricity. He was informed that precautions against that are specified in blower regulations, which apply here. The value of sprinklers was mentioned in that they at least control a fire if water cannot be relied upon to put it out. Sand and hand fire extinguishers should be available.

E. G. Richardson, of Berry Bros., Inc., Detroit, said that repeated tests of samples drawn from good spray-booths failed to show any that were rich enough to be explosive. He considers the primary hazard to be from pyroxylin dust that may be raised by any vibration and set off by a spark; hence, the importance of washing out every night is evident. There is probably more hazard in the small refinishing shops than in the factories.

A. C. F. Luke, of the Royal Canadian Air Force, told of trouble from fire caused on doped airplane wings when a workman was soldering copper wire. This he thought was the result of the catalytic action of copper, as explained in the paper. Trouble has been found also with certain soldering fluxes. He said they have found that sprinklers would not put out a fire in the linen but would prevent it from spreading to the wood of the frames.

Chairman Younger called attention to the possibility that the common copper-asbestos cylinder-head gasket may have an important influence on engine operation.

After the discussion of Mr. Miner's paper, A. R. Glancy, president and general manager of the Oakland Motor Car Co., gave an address. He has progressed by a devious route from being a young college graduate who could see no future in the automobile business to his present position, and he referred to Aladdin as a mere fumbling amateur compared with what the automobile industry has accomplished. He said in part that in the history of an individual or of a business there are three periods. The first is a time of ruthless struggle, when no "holds are barred." After this comes a time when the position gained must be stabilized. Then a mature period is reached when judgment and policies are respected. We are well into the third period of this industry. In it the great problem is that of selling, and the engineer can be of help in this problem.

Credit for some of the points made was given to Samuel Straus, economist, who teaches that we no longer produce in order to sell, we must sell in order to produce and to support the economic structure of the American public. We must produce more goods each year, because National prosperity depends upon it. Throughout the centuries the problem has been how to produce more goods. And now the problem is how to make men want more goods and use more goods than enough. This is called the science of plenty.

It is not now the problem of the engineer merely to make a certain part strong enough; it also should have selling appeal, and the production department must preserve that appeal in making the part. Mr. Glancy does not wish to make poor salesmen out of good engineers, but he believes that the engineers' influence should be more strongly felt in all departments, putting science into sales and accounting. Emerson's famous saying about the mouse-trap was splendid philosophy but vile selling. At least it will not work today. The romance of today is to beat the other fellow in a commercial way.

There is a lot of romance in the engineer. If he will let it get out he will become sympathetic with the selling side of the business. The engineer is almost the most rounded man in the industry. He is mentally trained, and he associates with cultured people, with forceful and successful people and with the toughest lad in the shop. Perhaps he fights shy of the salesmen, but he must remember that the problem is to sell automobiles at a profit.

Grinding Films Shown

Following Mr. Glancy's address, the room was darkened to show a four-reel film recently completed by the Norton Co., entitled, The Age of Speed. This was of interest both because it showed some of the recent grinding processes

which were covered in a paper read earlier in the day and because it is a good example of an industrial film. The introduction showed a number of contrasts between the slow methods of travel and of work of years ago and the travel and work of today, with automobiles, airplanes, express trains, and power and automatic machinery.

Captions accompanying the pictures brought out the fact that Watt's engine was not commercially practical until Wilkinson discovered how to bore cylinders with a degree of accuracy greater than had been available before, though it was far from the present standards of accuracy that are obtainable by grinding.

Interesting scenes were shown of Niagara Falls, where abrasives are produced in electric-furnace plants; also, scenes in the Norton plant at Worcester, Mass. Processes of molding, burning, and finishing of vitrified wheels were shown at length, and a considerable footage of film was devoted to operations being performed on uptodate grinding machinery.

FEATURES OF DETROIT EXHIBITION

New Developments Observed in Steels, Heat-Treating, Welding, and Testing

The Detroit sessions of the Production Meeting were held in cooperation with the American Society for Steel Treating, and the National Steel and Machine Tool Exposition held in Convention Hall, on Woodward Avenue, was of interest to many of the S.A.E. members. Because of the machine-tool exhibit held in Cleveland during the same week, the Detroit show was more distinctly than in the past an exposition of steels and of heat-treating, welding and forging equipment.

Most of the manufacturers of steel had exhibits of their tool steels and steels for fabrication, and there were a number of exhibitors of forged and cast steel, including one of rolled forgings produced with rolls in which die impressions are sunk, so that the desired forging shape is obtained directly from the rolling mill. Front axles and rear-axle shafts for automobiles are among the forgings produced in this way.

At many of the steel exhibits were shown fabricated products made from heat-resisting steel, among them being rolls and detachable-link chains for use in furnaces.

Variety of Electric and Gas Furnaces

A great variety of electric furnaces was shown, ranging from lead and cyanide pots to continuous annealing furnaces. A section of one of the latter was shown in which the work is carried on long arms projecting up into the heated chamber through narrow slots from chains below, located where they are not subjected to the full heat of the furnace.

As the ordinary metallic heating-element is useless for temperatures higher than about 1900 deg. fahr., several furnaces designed for use beyond that limit have bars of refractory material as heating elements. In one of these furnaces the bars are supported in water-cooled holders extending into the furnace, and in another the bars pass through the furnace walls to the air where the connections are subjected to less heat. Furnaces of this sort are available to give temperatures of 2400 to 2500 deg. fahr.

In one group were several gas-burning exhibits, representing the American Gas Association. They included some of the largest heat-treating equipment at the show, two with continuous roll-feed furnaces and some with other means of automatic feed. One unit was a vertical carburizing furnace utilizing some of the carbon from the gas, without the use of any other carburizing agent.

Many Test Instruments Displayed

There were many exhibits of pyrometers, cameras, optical instruments, and other equipment of interest to the metallurgist. Among them were two unfamiliar hardness-testing instruments. One of these, from a British manufacturer, has a square diamond pyramid and gives Brinell hardness figures directly over a large range of work. Since the pressure and area used are relatively small, this instrument is said to be

A View of the National Steel and Machine-Tool Exposition in Detroit

THE CHAIRMAN AND DISCUSSERS AT THE TIME-STUDY SESSION

E. J. Frounfelker (Lower Center), Who Presented a Paper on the Relation of Time-Study to Labor Budgets; Eugene Bouton (Upper Center), Who Presided at the Session; E. N. Sawyer (Left), and Erik Oberg (Right), Who Discussed the Papers

suitable for accurate work on thin material and for use without injury to highly finished surfaces.

The other unfamiliar instrument, made by a well-known American instrument firm, makes use of the pressure required to deform a certain area of the metal under test. A diamond point is used for hard steel or minerals and a ball for softer materials. In use, the impressor point is pressed into the sample to a definite depth that is not constant for all materials, and a reading is made of the number of kilograms of pressure required for this impression.

But not all of the exhibits were for the metallurgists primarily. For instance, there was a type of pin of European origin that has recently been introduced into this Country to take the place of taper and straight pins and rivets. This is made from a straight pin by rolling several V-shaped grooves of tapered depth. The pins are made slightly smaller than standard drill sizes, and where the V-grooves begin, the diameter of the pin begins to increase. In this way sufficient taper is given the pin so it will have a firm drive fit in a hole drilled with a well-sharpened drill. The deformation caused by the grooving is such that the metal will return nearly to its original form when the pin is driven.

FORGING, WELDING AND OTHER MACHINES

Forging and upsetting machines of several makes were shown in operation; also punch-presses and shears of both American and European build. Some of the European tools of this class looked strange to American eyes because the frames are thin and of deep section. Another machine of interest was a new type of wire-drawing machine producing a copper wire of a size suitable for ignition coils.

A number of exhibits featured welding and cutting equipment of various sorts. One such new tool was a portable electric welder having transformer coils carried near the welding points. This tool is of capacity sufficient for welding No. 16 gage steel, and is being used in automobile body-work. There was a variety of spot and seam welding equipment, and some examples of cutting torches guided by forms or arms for the production of predetermined forms.

Of interest in connection with oxygen-burning equipment was an outfit for extracting oxygen from the air by producing liquid air and the oxygen and nitrogen by evaporating at different temperatures. At least one such outfit is in use in an automobile plant. If 200,000 cu. ft. per month of oxygen is required, the total cost with such an outfit is said to be about 20 cents per 100 cu. ft.

There were also a number of exhibits of machine-tools, most of them of large general-service type, but a few were automatic lathes used for the production of automobile parts.

VARIED USES OF TIME STUDY

Applications to Equipment and to the Labor Budget Sometimes Neglected

Some of the neglected advantages of time study were pointed out in a paper written by J. C. Mottashed, president of the Society of Time-Study Engineers, and presented, in the absence of the author, by Harry Ford, of the Cadillac

(*Continued on p.* 444)

Photograph by Underwood & Underwood

THE START OF THE NATIONAL NEW YORK CITY-TO-SPOKANE AIR DERBY

First Aeronautic Session Held at Spokane

An attendance of 175 engineers, executives and Government and university representatives from all over the Country and the keen enthusiasm shown in aviation matters made the session of the Society's Aeronautic Meeting, held in Spokane on Sept. 23, a meeting of which any committee, organization or city could well be proud. The meeting was held at the Hotel Davenport starting at 8 p. m. and was presided over by Valentine Gephart, secretary of the National Aeronautical Association. The Pacific Coast Meeting Committee, to which credit for the great success of the meeting is due, was constituted as follows: Ethelbert Favary, of Los Angeles, chairman; Lees J. Burrows, Leo Drobig and Royal N. Riblet of Spokane; Robert S. Taylor, of Seattle; and John H. Watrous, of San Francisco.

One result of the enthusiasm demonstrated at the meeting was a decision to establish a member and student group of the Society for the State of Washington. The National Air Races of the National Aeronautic Association, run in Spokane during the week, made it very evident that much progress was made last year in commercial-aircraft design and that the use of old war material is being eliminated rapidly.

Hon. Edward P. Warner, assistant secretary of the navy for aeronautics, who originally expected to present a paper at Spokane, was unable to be present, and his place on the program was taken by Prof. F. K. Kirsten, of the aeronautic laboratory of the University of Washington.

INDUSTRIAL USES FOR THE AIRPLANE

In a paper entitled Put the Airplane to Work, C. F. Lienesch, aeronautic engineer of the Union Oil Co., presented a good outline of the potential industrial market for the airplane as a working tool but pointed out the great need for additional data. Some of the specific applications of the airplane which he mentioned are the transportation of mail, express matter and passengers from steamships at sea to the land; forest-fire patrol work and the transportation of men to the site of a fire; distribution of newspapers; and the carrying of payrolls.

Aircraft landing-fields in the cities are less expensive than railroad yards, he said, and their establishment can make cities the centers of influence in the sciences, as Rochester, Minn., is now a leading medical center. Airplanes can be used for the transport of patients to hospitals, for rescue work along shore, and by railroads for sightseeing trips by their passengers. He pointed out how the airplane could save passengers 24 hr. on the Grand Canyon trip. Such a flight in the hard-working airplane is not unduly hazardous or expensive.

PURELY COMMERCIAL DESIGNS NEEDED

Major C. C. Moseley, of the Western Air Express, Inc., operating on the Los Angeles to Salt Lake City airway, which is one of very few companies that are at present operating an airline at a profit, stated that he is strongly convinced that airplane military engineering-practice is too costly for commercial operation, in which the highest consistent cruising speed is needed rather than extreme high speed. The designing of airplanes for purely commercial purposes has hardly started, he asserted, and present designs are revamped military designs. For this reason they are uneconomical in operation. What is desired is the greatest cargo capacity combined with the highest speed consistent with the lowest operating cost. An adequate reserve of airplanes and engines must be maintained. Airplanes must be used that are not required to utilize their reserve power regularly.

The Western Air Express has attained low maintenance cost and has operated 700,000 miles in 17 months with only four forced landings due to mechanical trouble. Each airplane is operated only 1 day out of 3, remaining in the hangar 2 days for inspection and servicing. The engines are run from 150 to 170 hr. between overhauls. Present high cost of airplanes is due to limited production and to passing defects, according to Major Moseley, who predicted that within 10 years air transport will be as cheap as surface transportation except for bulk freight.

PROBLEMS IN TRANSPORT-AIRPLANE DESIGN

A paper on Problems in Design of Transport Airplanes, by C. N. Monteith, of the Boeing Airplane Co., was very favorably received. On account of trouble encountered in general, the designers lack information for suitable commercial designs. On the Chicago to San Francisco mail route the pilots fly at an altitude of 13,000 ft. to clear the mountain ranges and higher if the weather is cloudy. The pay-load on part of the route exceeds 1200 lb. but is necessarily much lighter on the Western part of the route because of the altitude that must be attained.

It is probable, the speaker said, that a different type of machine will be used for the lighter loads from Cheyenne westward. Alternative solutions of the problem are supercharging of the engine to 6000 ft., increasing the span loading and increasing the wing area. By increasing the gear-ratio to 10 to 1 the engine apparently can be supercharged

to 5000 ft. with an increase in ceiling for the military airplane to 4000 ft. with no increase of apparatus. This involves other problems, including a larger propeller and satisfactory cooling, the engine-speed being too great at the necessary power at present. Gearing down seems necessary but has not been solved satisfactorily. According to Mr. Monteith, the Fairchild-Caminez cam engine is a promising substitute for a geared engine, a propeller speed of one-half engine-speed being secured without gearing.

Balancing and Unloading Present Difficulties

Detail design determines passenger comfort in airplanes. Many difficult problems are connected with the cowling of air-cooled engines and with muffling of the engine exhaust. The manifold is heavy and reduces speed, as the manifold cannot be placed inside of or flat on the fuselage. Other problems are the balancing of the craft for light and full-load conditions and the unloading of mail and passengers quickly at intermediate stops. The author recommended placing the fuel tank in the lower wing, although this necessitates dependence on a gasoline pump. He is opposed to use of a straight running-gear axle for work over rough country. He said that rubber shock-absorbers are not satisfactory because they result in too much bouncing, which results in breakages. The use of an electric starter reduces the number of ground men.

It may perhaps be necessary, continued Mr. Monteith, to increase the number of controls for the purpose of controlling and retracting landing lights, although there are about 12 different controls in the cockpit now. Biplane construction is preferred by Mr. Monteith because the monoplane is difficult to repair and to make replacements at points far distant from parts stations. He regards the present airplane as far from perfect and said that 10 years of work has resulted in comparatively little knowledge. It is almost essential to replace the tail-skid with a wheel on large airplanes, as otherwise it is too difficult to get the craft under way.

Commenting on some of Mr. Monteith's statements, Arthur Nutt, of the Curtiss Aeroplane & Motor Co., stated that using a certain type of spring coupling which would absorb shock solves the gear-reduction problem. Many tests are being made on this coupling by the Army Air Corps. Water-cooled engines used at the flying-field during the week developed 735 hp. at an engine-speed less than the peak of the power curve and weighed 1½ lb. per hp., including the radiator.

Propeller with Rotatable Blades Described

Results of 5 years' research work on a new type of propeller were given by Professor Kirsten. This propeller consists of a rotor disc from which a series of blades project at right angles to the disc surface and are mounted so that they rotate on an axis lying in an orbit concentric with the axis of the propeller rotor. These blades rotate at one-half propeller speed and are so aligned that they reach in the most advantageous position regarding the windstream for the production of propulsive effort on the blades and are effective during the complete revolution on the orbit indicated.

This propeller has an indicated efficiency superior to that of the screw propeller, he said, a chief advantage being that the thrust may be directed along the desired line in a horizontal plane coincident with the rotor surface, and it has a promising application for dirigibles in replacing the static rudder and control surfaces with dynamic action. With this propeller mounted in the proper position along the hull, the difficulties of controlling landing and ballasting are reduced. Its application to heavier-than-air craft is being considered, and the propeller is now being tested in a wind-tunnel at the University of Washington.

Photograph by P. & A.

Mass Production of Airplanes on the West Coast—The Boeing Airplane Co. Plant

A great advance has been made in the last 4 years, asserted Lieutenant-Commander Kneip, in charge of Naval inspection at the Boeing Airplane Co.'s plant, due to practical experience which is based largely on Government service data that are given freely to commercial aviation. This is full justification for the Government expenditures made at McCook Field, as the personnel stationed there has produced results that the taxpayers will appreciate more and more as time passes than is possibly the case at present.

A welcome to the Western members of the Society was extended by Mr. Favary and was acknowledged and replied to by Secretary Coker F. Clarkson, who expressed appreciation of the assistance extended by members and the Spokane representatives and thanked them for the excellent work that they have done in connection with the holding of the National Air Races.

The Aeronautic Meeting—Oct. 18 to 20

Requests received for copies of the program indicate keen and widespread interest in the forthcoming Aeronautic Meeting. Moreover, comments made upon the program by leading aeronautical engineers are of such an appreciative nature as to lead to the conclusion that the committee in charge of arrangements for the meeting have planned a most attractive event.

The Society's Annual Aeronautic Meeting will be held in the roof garden of The Waldorf-Astoria, New York City, Oct. 18, 19 and 20. A perusal of the technical program printed herewith will undoubtedly suffice to convince every engineer concerned with aeronautics that he cannot afford to miss a single one of the sessions. The opportunity for the visit to Hadley Field is one which no one attending the technical sessions would be willing to forego. Detailed comment upon the papers to be presented and the speakers who are to deliver them is not necessary.

Trip to Hadley Field

Unusual interest attaches to the inspection visit that has been planned as a part of the Aeronautic Meeting. Arrangements have been made for those desiring to take this trip to leave New York City early in the evening of Wednesday, Oct. 19, reaching Hadley Field, New Brunswick, N. J., about 8 o'clock. Shortly after the arrival of the party, H. E. Mahan, of the illuminating engineering laboratory of the General Electric Co., will give a talk on the subject of designing and laying out the lighting for an airport. Then a thorough demonstration of the lighting system now in use at Hadley Field will be given. Several types of experimental lighting will be seen, as well as standard equipment. The party will probably be at the Field when the Chicago mail departs.

Metropolitan Section Meeting

The program of the National Aeronautic Meeting really ends with the session on the afternoon of Thursday, Oct. 20, in the concluding paper of which John Nolen, of Cambridge, Mass., will discuss The Place of an Airport in a City Plan. However, the meeting of the Metropolitan Section, on airports, scheduled for the evening of the same day, forms a fitting epilogue to the Society's meeting. Charles H. Colvin, of the Pioneer Instrument Co., will preside at the Section

Aeronautic Meeting Program

The Waldorf-Astoria—New York City

Tuesday, Oct. 18

2:00 P.M.—Afternoon Session

Alexander Klemin, *Chairman*

Studies in Metal Construction—Papers by W. B. Stout, Stout Metal Airplane Co.; Charles W. Hall, Charles W. Hall, Inc.; I. I. Sikorsky, Sikorsky Aero Engineering Corporation; Jean Roche, Army Air Corps; and Commander R. D. Weyerbacher, Naval Aircraft Factory

Wind-Tunnel Testing—E. N. Fales, Army Air Corps

8:00 P.M.—Evening Session

Edward P. Warner, *Chairman*

Technical Problem of Control of Air Worthiness—Papers by C. M. Young, Department of Commerce; and E. W. Stedman, Royal Canadian Air Force

Monoplane or Biplane—C. H. Chatfield, Massachusetts Institute of Technology

Single Versus Multi-Engine Planes—A. H. G. Fokker, Atlantic Aircraft Corporation

Wednesday, Oct. 19

2:00 P.M.—Afternoon Session

W. L. LePage, *Chairman*

Oversea Navigation—Lieut. Arthur Hegenberger, Army Air Corps

The Engineering of the Department of Commerce Airways—F. C. Hingsburg, Department of Commerce

Instruments for Oversea Navigation—Victor E. Carbonara, Pioneer Instrument Co.

The Direct Application of Commercial Aircraft in the Naval Service—Hon. Edward P. Warner, Assistant Secretary of the Navy for Aeronautics

Evening Session

Inspection Visit to Hadley Field, New Brunswick, N. J.
Paper: Designing and Laying Out the Lighting for an Airport—H. E. Mahan, General Electric Co.

Thursday, Oct. 20

2:00 P.M.—Afternoon Session

H. M. Crane, *Chairman*

Calculated and Actual Performance of Supercharged Engines—Opie Chenoweth, Army Air Corps

Maintenance of Wright Air-Cooled Engines in Commercial Operation—C. H. Biddlecombe

The Place of an Airport in a City Plan—John Nolen

8:00 P. M.—Metropolitan Section Meeting on Airports

Charles H. Colvin, *Chairman*

Design and Construction of Airports—William E. Arthur, William E. Arthur & Co.

A Commercial Airport for New York City—Hon. William P. MacCracken, Jr., Assistant Secretary of Commerce for Aeronautics

Airports and Their Relation to Commercial Aviation—Gen. J. F. O'Ryan, Colonial Air Transport, Inc.

meeting, at which the following papers will be presented: Design and Construction of Airports, by William E. Arthur, of William E. Arthur & Co.; A Commercial Airport for New York City, by Hon. William F. MacCracken, Jr., assistant secretary of commerce for aeronautics; and Airports and Their Relation to Commercial Aviation, by Gen. J. F. O'Ryan, president of the Colonial Air Transport, Inc. All persons attending the Society's Aeronautic Meeting are cordially invited to attend this meeting of the Metropolitan Section.

Another Meetings Bulletin

Further details regarding the 1927 Aeronautic Meeting will appear in the next issue of the *Meetings Bulletin*, which will be mailed about a fortnight prior to the opening of the meeting.

Preprints of many of the Aeronautic Meeting papers will soon be available. Members wishing to secure copies for study and for the purpose of preparing discussion in advance of the meeting should notify Society headquarters immediately, stating clearly which paper or papers they wish to obtain.

Committee Personnel

Arrangements for the 1927 Aeronautic Meeting have been made under the capable direction of the following committee: Hon. Edward P. Warner, assistant secretary of the navy for aeronautics, chairman; Lieut. E. E. Aldrin, of the Army Air Corps; H. M. Crane, of the General Motors Corporation; E. T. Jones, of the Wright Aeronautical Corporation; Alexander Klemin, of New York University; W. L. LePage, of the Pitcairn Aviation, Inc.; L. D. Seymour, of the National Air Transport, Inc.; and J. A. C. Warner, of the Studebaker Corporation of America.

The Transportation Meeting—Oct. 25 to 27

An attempt to count the persons in this Country who are interested in or affected by automotive transportation would unquestionably lead to a duplication of the work performed periodically by the census takers. In view, therefore, of the far-reaching effects of anything done to accelerate or retard the progress of this important branch of the automotive industry, the program of the 1927 Automotive Transportation Meeting should make a widespread appeal, because at that meeting papers will be presented and talks will be made by a score of persons eminently qualified to discuss the technical problems pertaining to this phase of automotive work.

Six technical sessions and a banquet comprise the program arranged by the Transportation Meeting Committee for the meeting, which will be held in the crystal room of Hotel Sherman, Chicago, Oct. 25 to 27. At the sessions, such topics as maintenance, operation, freight handling, motor-trucks, rail-cars, and motorcoaches will be discussed. The program, printed herewith, gives such details regarding papers, authors and session chairmen as to make further comment unnecessary at this time.

The Transportation Banquet

Members of the Committee are to be congratulated upon securing, as toastmaster for the Transportation Banquet, T. C. Powell, president of the Chicago & Eastern Illinois Railway Co. With Mr. Powell as toastmaster and Brigadier-Gen. F. H. Pope, of the Quartermaster Corps, United States Army, as the chief speaker, the success of the banquet is assured.

Members of the Society who are planning to attend the banquet will find it advantageous to make reservations immediately, by sending to Society headquarters a check for the ticket or tickets they wish to obtain.

Edward Wotton, of the Chicago Motor Coach Co., a member of the Transportation Meeting Committee, who is in charge of inspection trips during the meeting, has made

arrangements whereby members may register at the Society's information desk at the time of the meeting for a visit to one of the following places: Arthur Dixon Transfer Co., Chicago Motor Coach Co., Underwriters' Laboratories, or Yellow Truck & Coach Mfg. Co. The times at which these trips will be made will be announced later.

Watch for Meetings Bulletin

On Oct. 11 a *Meetings Bulletin* will be mailed to all members, giving further information about the Automotive Transportation Meeting. Any change of plans regarding the meeting that may meanwhile be found necessary will be printed in the Bulletin.

Preprints of Papers Available

Papers received sufficiently in advance of the meeting will be preprinted. Members desiring copies prior to their presentation should notify Society headquarters regarding the paper or papers desired. It is hoped that members securing preprints will contribute written discussion of the papers in which they are particularly interested.

The Committee

Plans have been formulated and arrangements made for the Automotive Transportation Meeting by the following committee: F. J. Scarr, of the Scarr Transportation Service, chairman; H. C. Crowell, of the Pennsylvania Railroad Co.; H. L. Debbink, of the Milwaukee Electric Railway & Light Co.; F. I. Hardy, of the Boston & Maine Railroad Co.; F. C. Horner, of the General Motors Corporation; R. E. Plimpton, of *Bus Transportation;* F. G. Whittington, of the Stewart-Warner Speedometer Corporation; J. F. Winchester, of the Standard Oil Co. of New Jersey; and Edward Wotton, of the Chicago Motor Coach Co.

Transportation Meeting Program

Hotel Sherman—Chicago

Tuesday, Oct. 25

10:00 A. M.—Maintenance Session

J. F. Winchester, *Chairman*
(Standard Oil Co. of N. J.)

Maintenance on the West Coast—E. C. Wood, Pacific Gas & Electric Co.

Army System of Maintenance—Lieut. W. C. Thee, Quartermaster Corps, United States Army.

Shop Equipment and Tools—Martin E. Goldman, Automotive Equipment Association.

Exhibit of Shop Equipment and Tools.

2:00 P. M.—Operation and Maintenance Committee Session

R. E. Plimpton, *Chairman*
(*Bus Transportation*)

West Coast Subcommittee Report—E. C. Wood, Pacific Gas & Electric Co.

Nomenclature Subcommittee Report—F. K. Glynn, American Telephone & Telegraph Co.

Accounting Subcommittee Report—R. E. Plimpton, *Bus Transportation*

Regulations Subcommittee Report—F. J. Scarr, Scarr Transportation Service.

Wednesday, Oct. 26

10:00 A. M.—Freight-Handling Session

F. I. Hardy, *Chairman*
(Boston & Maine Railroad Co.)

General Theory of Containers—Bernard Allen, Scarr Transportation Service

Application and Operation of Containers—G. C. Woodruff, L. C. L. Co.

Tractor - Trailer - Container Terminal Handling of Freight—E. E. LaSchum, American Railway Express Co.

2:00 P. M.—Motor-Truck Session

F. C. Horner, *Chairman*
(General Motors Corporation)

Problems in Long-Distance Transportation—G. R. Gwynne, Continental Oil Co.

Application of Operating Cost Systems—A. W. S. Herrington, Consulting Engineer

Common-Carrier Trucking under State Regulation—E. L. Murphy, Jr., Murphy Transportation Co.

7:00 P. M.—Annual Transportation Banquet

T. C. Powell, *Toastmaster*
(Chicago & Eastern Illinois Railway Co.)

Transportation—G. W. Dixon, Arthur Dixon Transfer Co.

Relation of Commercial to Army Transportation—Brigadier-Gen. F. H. Pope, Quartermaster Corps, United States Army.

Thursday, Oct. 27

Rail-Car and Motorcoach Session

H. C. Crowell, *Chairman*
(Pennsylvania Railroad Co.)

10:00 A. M.—Morning Program

Rail-Car Design and Operation—W. C. Sanders, Timken Roller Bearing Co.

Rail-Car Fuels—E. Wanamaker, Chicago, Rock Island & Pacific Railway Co.

Rail-Car or Motorcoach, the Economic Field of Each—H. F. Fritch, Boston & Maine Railroad Co.

2:00 P. M.—Afternoon Session

Motorcoach Design—K. J. Ammerman, American Car & Foundry Motors Co.

Today's Motorcoach Legislation—R. H. Newcomb, New York, New Haven & Hartford Railroad

Tomorrow's Motorcoach Legislation—A. M. Hill, Midland Trail Transit Co.

Automotive Research

For the automotive industry one of the most encouraging features of the headlighting situation is the dissatisfaction with it. Criticism of the present lighting provisions for night driving and the constant demand for improvement in equipment means that the public will not accept the complexity of the headlight question as an insuperable obstacle to its solution. Car owners are not content to dispense with their means of individual and flexible transportation between the hours of sunset and sunrise; the automobile must be more than a daylight utility.

Moreover, the public is trying to find its own solution. If the number and subject distribution of the letters that come to the Research Department may be taken as a criterion, no other automotive topic is more attractive to those of speculative and inventive mind in all walks of life. Schemes for the arrangement of headlights or specific devices are continually being suggested in the many communications received.

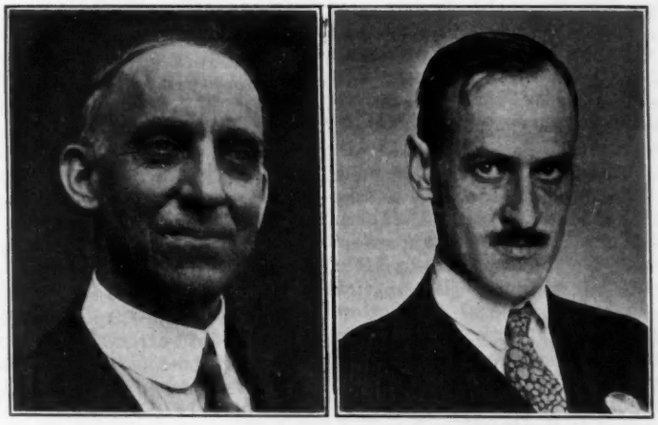
It is only justice to the interests more closely associated with the automotive field to bring to general attention, from time to time, the efforts that these interests are making to increase the expediency and safety of night driving. One line of endeavor is to study the fundamentals of illumination for night driving, with the object of evolving light patterns and light intensities that are ideal for attaining visibility and avoiding glare. A short statement on such an investigation, prepared on information furnished by Dr. H. C. Dickinson[1] and H. H. Allen[2], is the first section of Automotive Research. With funds generously contributed by the National Automobile Chamber of Commerce, this project is being carried out at the Bureau of Standards under the technical direction of the Research Committee of the Society and the direct supervision of Dr. Dickinson, its chairman.

Another line of endeavor is to improve the effectiveness of present equipment. This is illustrated in the Instructions for Head-Lamp Adjusters at Designated Testing Stations prepared by Alfred W. Devine[3]. to be used in conjunction with Head-Lamp Instructions (Form 57) of the Registry of Motor Vehicles, Commonwealth of Massachusetts, which is presented as an example of what one State is doing to educate service men.

PROGRESS IN FUNDAMENTAL HEADLIGHT RESEARCH

Speaking at the Headlight Session of the 1927 Semi-Annual Meeting, Dr. Dickinson touched on some of the phases of the headlighting situation that render it so difficult to deal with. Headlights, he said, are probably the only adjunct to present stock automobiles which the public, as well as the engineers, very generally condemn as unsatisfactory. Various reasons may be advanced for this, one of which is the complexity of the problem of securing good road illumination without intolerable glare to the approaching driver; others are the technical difficulties in making good headlight adjustments and lack of rigidity and permanence of the head-lamp equipment.

The lowering of the driver's seat and the increase in spring flexibility in recent car models have seriously increased the difficulties in securing good driving light without glare by methods formerly employed and now incorporated in some of the State laws. On the other hand, recent developments in the design of head-lamps and renewed activity in the study of the entire headlighting problem give promise of radical, and possibly revolutionary, improvements in road illumination by the use of systems better adapted to meet present conditions.



ACTIVE INVESTIGATORS OF HEADLIGHTING FUNDAMENTALS; DR. H. C. DICKINSON (LEFT) AND H. H. ALLEN (RIGHT)

Another consideration generally urged is that, while some improvement has been brought about in this situation due to the enforcement of present headlight regulations, this is likely to be, in the future as in the past, of a sporadic nature and not a remedy to be applied to accomplish the desired result. In fact, a great difference of opinion exists as to just what is the desirable result in headlighting. This leads to confusion and misapprehension, which serve only to muddy waters that already are murky.

In view of the need of further progress and the prospect of important improvement it was proposed to undertake a systematic study of the types of light distribution required for safe and satisfactory vision on the different classes of road under all usual driving conditions, with a view first to optimum illumination in absence of any traffic proceeding in the opposite direction and second when meeting vehicles.

It was hoped that a systematic study of this problem will do away with many of the present headlighting difficulties and perhaps put the lighting on as satisfactory a basis as other features of car design.

The problem of how to provide proper road illumination has been regarded, in planning the present research, from

[1] M.S.A.E.—Chief of the division of heat and power, Bureau of Standards, City of Washington.

[2] Assistant mechanical engineer, Bureau of Standards, City of Washington.

[3] M.S.A.E.—Engineer in charge of equipment section, Registry of Motor Vehicles, Commonwealth of Massachusetts, Boston.

two principal viewpoints, namely (*a*) to provide illumination sufficient in amount and so disposed in the space into which the vehicle is about to move that any objects may be plainly seen a sufficient distance ahead so that the vehicle may be stopped before collision with them, regardless of the speed at which the vehicle may be traveling; and (*b*) to provide illumination sufficient for the same purposes when approaching vehicles are to be met and passed, so that there will be a minimum of danger or discomfort to the approaching driver.

It is well-nigh impossible to fulfil both of these requirements with a single type of illumination. The present headlight regulations are, for the most part, an attempt at a compromise between these two major requirements, and they neither provide for means of obtaining the maximum visibility and safety, on the one hand, nor for the minimum discomfort to the driver, on the other hand. This is assuming, as is not always the case, that we are discussing headlight illumination which complies in every respect with the legal requirements. Data are available to show that a very considerable volume of night traffic does not comply with the regulations.

The foregoing discussion brings out the following points:

(1) Optimum road illumination, with consequent night-driving safety and comfort, is not being provided

(2) Maximum safety and comfort for the driver are not afforded by any of the present headlighting equipments, either from the standpoint of danger or discomfort produced by the oncoming lights, or from that of the sufficiency or improper distribution of his own lights in the face of oncoming lights

(3) Maximum safety and comfort for the approaching driver may not be obtained by dimming of the lights on the car he is approaching.

(4) Maximum road illumination may not be obtained in accordance with present headlight regulations

(5) Maximum road illumination is not obtained, in many instances, even in violation of the present regulations, whether such violation be unintentional or by design.

The present investigation has for its purpose the determination, by experimental methods, of a standard of highway illumination. The method being pursued is one by which definite data may be obtained as to the kind, type and intensity of illumination which will show objects on or at the side of the road plainly, while driving both with and without approaching lights. The conclusions to be drawn from such data will be of great benefit to all persons who own automobiles, and a basis will have been formed for the elimination of one of the sales resistances with which the manufacturer now has to cope.

It is not to be expected, or even hoped, that a final solution of a problem so fraught with psychological and physiological as well as physical variables can be found. What is hoped for and expected is that much of the misapprehension, doubt and discomfort may be removed from night driving by providing standards of highway illumination which have as their basis a sound experimental foundation.

It is also expected that, by the interchange of data and experience that will be made, this result will be accomplished in a much shorter time than would be possible by other means, considering the complexity and difficulties accompanying the problem. Also, a more comprehensive view and, consequently, a wider range of experiences, will be available for correlation than would otherwise be the case.

Brief Summary of Work Done

The first part of the work done consisted of taking observations of the distances a given object could be seen. In this instance a dummy of the size and shape of a man was used. In every case the visibility distance was taken as that distance at which the object was distinguishably visible. Observations were taken on a straight course, essentially level, distances being marked off every 50 ft. on the course. The roadway was concrete.

Observations were taken varying the vertical spread, the horizontal spread and the tilt of the beams. A sufficient number of combinations of these variables was employed so that comprehensive data were obtained and a set of three-dimensional, or solid, graphs were made showing these data to scale. The data serve as a groundwork for reference as well as to show definitely the relations existing.

The work was done within the limits of 2 to 40 deg. horizontal spread, 2 to 10 deg. vertical spread and of 3 deg. elevation to 3 deg. depression of the beam, and various combinations of these factors. In addition to introducing these variations, different beam intensities were used, and the visibility was determined for a number of types of beam, as well as the differences in visibility while traveling at various speeds from a walk up to, or slightly above, 40 m.p.h.

Conclusions arrived at as a result of these experiments follow:

(1) The visibility distance decreases as the horizontal spread of the beam becomes greater; rapidly between 2 and 10 deg., and less rapidly between 10 and 40 deg.

(2) The visibility distance decreases enormously as the beam is elevated or depressed, particularly for beams of narrow horizontal spread and small vertical spread

(3) The visibility distance practically does not vary for all tilts from 3 deg. elevation to 3 deg. depression when vertical spreads in excess of 6 deg. are used

(4) The darker the night the greater the visibility for a given beam intensity and pattern

(5) Conditions in fog indicate that the beam intensity needs to be diminished and spread laterally more than would otherwise be satisfactory

(6) Visibility is virtually the same for all spreads between a walk and 40 m.p.h.

All of the data mentioned were obtained without any light approaching the driver, and the conclusions refer only to this condition.

To Consider Effect of Approaching Lights

The data collected under this procedure are regarded as sufficiently comprehensive to justify the discontinuance of this portion of the program, at least for the present.

The work now begun and that contemplated for some time to come will be of a statistical nature and will consist of obtaining visibility distances employing two cars, one following the other, the first car being equipped with the S.A.E. and the Illuminating Engineering Society Headlight Test Equipment on the rear at normal head-lamp height. Observations will be taken by the following car on a test target attached to the right front door of the first car. The two set-ups are essentially alike except as described.

According to the present plan, a large number of observations will be made on every available type of roadway in the vicinity of the City of Washington, employing various horizontal and vertical spreads and various tilts of the beam on either or both cars. Control data will be obtained by making observations with the lights of the first car alternately on and off. In every instance this car will be on the left side of the road; that is, in the position normally occupied by an approaching car, and the test target will be in the right of way of the following car and about 5 ft. beyond the lights.

In addition to the visibility distance, the visibility of the road shoulder will be noted; a photometric observation of the beam intensity in the driver's eyes will be taken; the effect of the relative position, up and down, right and left, of the beams from both cars will be observed; and such other observations will be made as may subsequently be deemed to be valuable.

In this way the second half of the headlighting problem, that of protecting the driver of an approaching car from being seriously and even dangerously inconvenienced by glaring lights will be systematically and thoroughly investigated.

The cars will be run under every conceivable condition that could be met with in practice; that is, up hill, down hill, around curves, over depressions, at the tops and bottoms of hills, over smooth and rough roads, on dark nights and bright nights, and in rain, fog, wind, and sleet.

INSTRUCTIONS FOR HEAD-LAMP ADJUSTERS[4]

The applicant for approval as a head-lamp adjuster must be connected with a station which is suitable for designation and which has certain necessary equipment. The applicant himself must be familiar with head-lamp adjusting and with certain causes of improper or inadequate head-lighting and the cure for them. No applicant will be approved unless the equipment is satisfactory and unless he himself is thoroughly competent.

ALFRED H. DEVINE

EQUIPMENT

A dark level test-space at least 40 ft. long and 10 ft. wide, with a smooth substantial floor.

A fixed target at the end of the test space. The target is to be 10 ft. wide and at least 4 ft. high. It is to be painted *flat* white; a glossy surface cannot be used. A suitable wall may be used for the target or the latter may be especially constructed of some substantial material such as beaver-board attached to a frame and permanently fixed in position.

Two uprights or cleats must be secured to the target. They should be about 3 ft. apart and equally spaced from the center of the target. These uprights may be of 2 x 1-in. strapping and must have holes drilled in them every inch apart from 24 to 40 in. above the level surface.

Two dowel pins must be provided, one for each upright, to support the cross-bar.

A cross-bar is required which should be about 5 or 6 ft. long. This may be of light tubing or other suitable material which is not too thick and which does not bend.

A white line on the floor or some other suitable permanent marker must be located 25 ft. from the screen. This designates the position of the head-lamps while being adjusted.

INSPECTION

Arrangement.—Place the car on the testing stand so that the center of the car points approximately to the center of the target and so that the head-lamps are 25 ft. from it.

Approved Device.—Make sure that an approved device is used. These are divided into three classes: lenses, reflectors and complete head-lamps.

Approved lenses are marked with the complete approved name, in full view when the lens is installed. (See the latest list issued by the Registry of Motor Vehicles of the Commonwealth of Massachusetts.) They must be used with parabolic reflectors, such as the ordinary type commonly used on all Ford and most other cars for years.

Approved reflectors may be used only with clear plain front glasses. No so-called lenses may be used in front of such reflectors. The complete approved name is stamped into the reflecting surface near the bottom.

Approved head-lamps must be used as units. The complete head-lamp is the approved device. No substitution of other kinds of part is permissible. The approved name is stamped into the top of the lamp shell and the upper flange of the reflector, and is molded into the lens. No other head-lamp devices than complete head-lamps are now being approved by the Registrar, although lenses and reflectors which are still on the approved list may be used legally as specified above.

The Bulb.—Examine the bulbs. These must be 21 cp. and of the gas-filled type. They have a finely coiled V-shaped filament. Do not use any so-called "gyp" bulbs. Discard those which have exceptionally long or improperly shaped or sagging filaments, and those which have filaments that are not centered in the bulb. Discard bulbs which show signs of blackening or a whitish discoloration on the inside of the glass. These are inefficient and no longer give 21 cp. None but clear-glass bulbs may be used. The latest type of bulb has corrugations near the end.

The Reflector. — Tarnished or dirty reflectors must be polished. Those which are dented or have the silver-plating worn off must be replaced. See that there is packing between the reflector and the cover glass.

If one of the approved reflectors is used, it must be installed with the stripes straight up and down so that the name on it reads correctly.

The Lens.—The front glass, except the clear plain glass used with approved reflectors, must be installed right side up so that the name reads correctly and so that it cannot twist around in the lamp door.

The Focusing Mechanism.—This is provided in the ordinary automobile head-lamp for the purpose of moving the bulb forward and backward in the reflector. The single-screw type is usually built as shown in the accompanying Fig. 1. A very few head-lamps have the focusing screw reversed and the screwhead projects through the reflector flange. It is operated by removing the lamp door.

With focusing mechanism with two adjusting-screws such as is used in the Parabeam head-lamp and the Twin Beam head-lamp, the upper screw is like that shown above and moves the bulb forward or backward. The lower screw moves it up or down.

Whatever the type of focusing mechanism, see that it works freely and that the coiled spring is sufficiently strong to keep the bulb socket from moving accidentally. Repair or replace any part of the focusing mechanism which has stripped screw-threads.

ADJUSTMENT

Focusing Fixed Beam Single-Filament, Single Screw.—Light the head-lamps and cover one of them. Focus the other by turning the focusing screw to right or left until the beam on the target is as shallow as possible, with a clear upper outline. Watch the upper outline. Sometimes the best beam, with the sharpest cut-off, is obtained when the beam is not quite so narrow as it can be made. Turning the bulb over may improve the results; try it if the beam does not look right, and select the best beam-pattern of the two. When a bulb is replaced, the lamp must be focused and aimed again. Focus with the lenses in place unless the ad-

[4] Copyrighted by Alfred W. Devine.

justment is of the "inside" type. In the latter case focus with two lenses off, and get the smallest circular spot on the target.

Focusing Fixed Beam Single-Filament, Fixed Focus.—The Ryan-Lite head-lamp is the only one of this type approved. The location of the filament cannot be changed except by selecting a bulb which has the filament differently placed. A few other head-lamps without any focusing mechanism have been built, but this has been done without the sanction of the Equipment Section of the Registry of Motor Vehicles. In such cases it will be necessary to try a number of different bulbs to secure one which gives the desired results. If the proper results cannot be obtained, the reflector should be replaced by one which has a focusing adjustment.

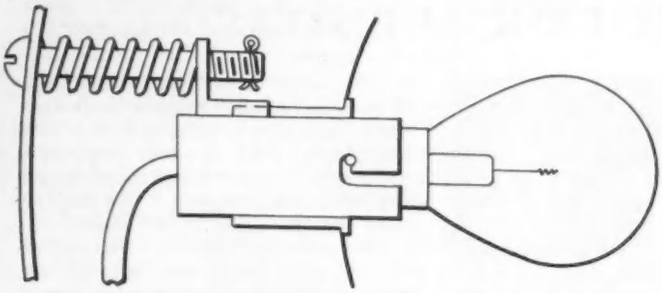


FIG. 1—SINGLE-SCREW TYPE OF ADJUSTMENT MECHANISM
The Lamp Is Moved Forward or Backward in the Reflector by Turning the Screw. In a Few Lamps the Arrangement Shown Here Is Reversed and the Screw-Head Projects through the Reflector Flange

A few head-lamps have also been built which have a set-screw through the reflector sleeve to hold the socket in a fixed position. These may be adjusted by loosening the set-screw and moving the socket forward or backward to get the desired results. In such cases make sure that the filament has its greatest width crosswise and not up and down when the reflector is installed. Focus to get the smallest circular spot and again tighten the set-screw in position.

Focusing Tilting Beam Double-Filament, Single Screw.—Head-lamps of this type now approved are: Depress Beam, Dualite, Duray, Tilt Beam, and Tilt Ray. The bulbs have two 21-cp. filaments. The lower filament gives the upper beam. Make sure that the beam-tilting switch is in the "high-beam" position and that the lower filament of each bulb is lighted. If the upper filament of a bulb lights when the switch is in the "high" position, reverse the plug connector in the back, or bottom, of the head-lamp, or shift the wires in the plug. (Note that the plug connectors in some head-lamps, notably those on Buick cars, are not reversible, so that if the wrong filament lights the wires must be reversed in the plug.) Then focus this upper beam as described in Paragraph 1 above. Do not attempt to focus the lower beam.

Focusing Tilting Beam Double-Filament, Double Screw.—Head-lamps of this type now approved are: Parabeam and Twin Beam. Both screw-heads project through the back of the lamp. The upper focusing screw moves the bulb forward and back, the lower screw moves it up and down. Make sure that the beam-tilting switch is in the "high-beam" position so that the lower filament of each bulb is lighted, as instructed in the preceding paragraph above. Focus one lamp at a time by turning the upper focusing screw to right or left until the beam on the target is as shallow as possible. Repeat this process with the lower focusing screw. Then alternate from one screw to the other until the shallowest beam, or that of greatest concentration, is obtained. Do not disturb the upper focusing screw after this result is obtained. Switch back and forth from "high" to "low" beam and make a final adjustment with the lower focusing screw until the top of the beam on the target tilts about 12 in. It is not necessary to reverse the bulbs in such lamps.

Aiming.—After the lamps are focused, and with the lenses installed, the head-lamps must be pointed in the proper direction with the beam straight across the target. Most head-lamps are mounted on an adjustable support. Loosen the adjusting nut or nuts and, after aiming the lamp, tighten the nuts securely. The Ryan-Lite head-lamp is aimed by turning the screw-head which projects through the back of the lamp casing. This tilts the whole reflector up or down. On old Ford cars and some other makes no aiming adjustment is provided and it is necessary to bend the lamp-supporting brackets or else shim them properly.

Measure the distance from the floor to the center of the head-lamp. Subtract the loading allowance shown in the table below and set the cross-bar on the uprights at that height. Aim the lamps, with the car empty, so that the top of the beam comes even with the cross-bar on the target.

Example: 1924 Ford Runabout

Height to lamp centers	32 in.
Loading allowance	3 in.
Set cross-bar at	29 in.

	Loading Allowances	
	Fixed-Beam Head-lamps, In.	Tilting-Beam Head-lamps, Upper Beam, In.
All passenger cars with a single seat	3	1
Medium-weight and heavy cars, five or seven passenger	5	3
Light five-passenger cars, wheelbase 110 in. or less	7	5

This loading allowance is extremely important. Be sure to allow at least as much as that stated above with the car empty. The aiming adjustment on motorcoaches and commercial vehicles should be made with a maximum load on, so that the top of the beam is 2 in. below the level of the lamp centers, plus 1-in. tilt in addition for every 4 in. higher than 42 in. that the lamps are mounted.

FUNDAMENTAL PRINCIPLES

The kind of a beam, intensity and distribution, which a head-lamp gives depends upon the front glass or lens, the shape of the reflector, and the size, shape and location of the filament. In general, it may be said that head-lamps are designed to produce a relatively shallow but wide beam, free from shadows in the beam and with a relatively sharp and clear top cut-off line.

Lenses are ordinarily built with curved and angular surfaces which are called cylinders and prisms. Usually the cylinder is used to spread the light sidewise and the prism to bend the light downward, as shown in Fig. 2.

Parabolic reflectors are used with all approved lenses, and in some approved head-lamps. These reflectors are so shaped that if the glowing filament is located at a definite point called the focus, all the reflected light-rays will be parallel until intercepted by a lens, as shown in the top view of Fig. 3. The effect on the direction of the rays of locating the light source at various points removed from the focal

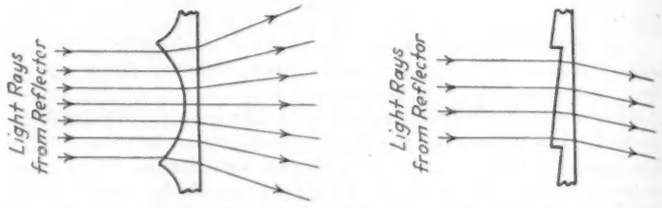


FIG. 2—CYLINDRICAL AND PRISMATIC SURFACES OF LENS, SECTIONAL TOP AND SIDE VIEWS RESPECTIVELY
Usually the Cylindrical Surface, as Shown at the Left, Is Used To Spread the Light Sidewise, and the Prismatic, Shown at the Right, To Bend the Light Downward

point is shown in other views of Fig. 3. If the filament is moved ahead of the focus, the reflected rays cross each other, and if the filament is moved back of the focus, the rays spread. If the filament is moved down, the rays are reflected up, and if moved up, the rays are reflected down.

The last two sketches in Fig. 3 show the operation of the two-filament tilting-beam bulb. When the switch is thrown from the lower filament to the upper filament, the beam tilts from high to low.

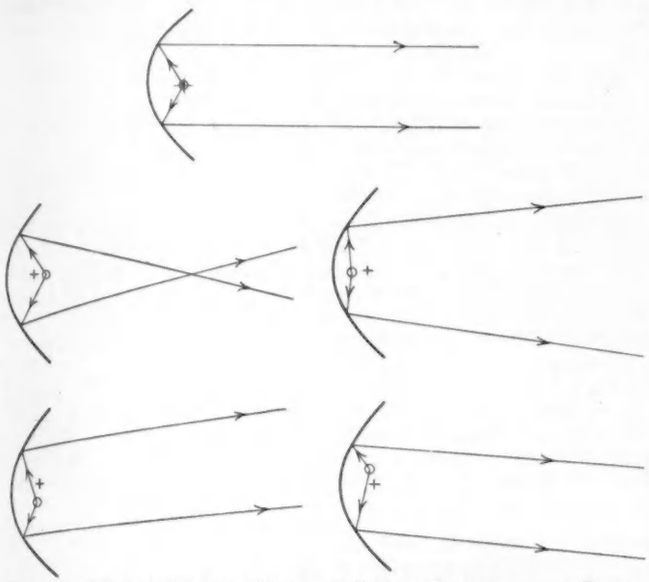


FIG. 3—DIAGRAMMATIC VIEW OF LIGHT BEAMS WITH PARABOLIC REFLECTOR

In the Top View Is Shown the Parallel Reflection of the Light Rays Which Is Produced When the Glowing Filament Is at the Focal Point, Indicated in These Sketches by a Cross. The Four Other Figures Show the Distortion of the Rays When the Light Source Is Removed in Various Directions from the Focal Point. The Last Two Figures also Show the Operation of the Two-Filament Tilting-Beam Bulb

HEAD-LAMP DEFECTS

Improperly shaped reflectors of all kinds, parabolic, striped, or specially shaped, and improperly located lamp-filaments are the cause of frequent trouble in service. A slight change in the shape of the reflector surface which can hardly be detected by eye is sometimes sufficient to distort the beam and make it unsatisfactory. In such a case good results will not be obtained until the reflector is replaced. Fortunately, this defect is not so common as the one which is now to be described. More often, in manufacture, the reflector will spring back near the rim while being punched out of the blank, resulting in a so-called "reverse curve" at the rim of the reflector. Light from the filament which strikes this reverse curve will be thrown off at an angle and is usually projected upward from the upper rim. If it happens that a lens, like the Monogram or the first-model Smith lens, which spread the light from the top center of the reflector very little, is used with such a reflector, considerable glare will result. It may often be eliminated by painting the reflector rim at the top with flat black paint in a band about ¼ or ½ in. wide.

Improperly located lamp-filaments may be due to the faulty construction of the bulb or to the faulty construction of the sleeve in the reflector in which the lamp socket slides. Recently trouble has been encountered with certain reflectors which could not be focused properly because the reflector sleeve was improperly located in the reflector and held the lamp filament too high. This may be corrected by tipping the socket sleeve down; hold a punch against the front lower edge of the sleeve and tap lightly. Before attempting to change the location of the reflector sleeve, make certain that the difficulty is due to a misplacement of it. You can do this by focusing the lamp as well as possible, then pushing the bulb up or down with a pencil, at the same time watching the appearance of the light pattern on the target. In some cases you may find it possible to correct for improperly placed socket-sleeves by using inaccurate bulbs which have filaments misplaced in the opposite direction.

We have had complaints of head-lamps built with too long a spring around the focusing screw. In some such cases it has been impossible to pull the bulb back into focus. The cure is to cut off a part of the spring, but do not cut off more than half a coil at a time.

Many cases of insufficient light are due to inefficient bulbs; poor contacts in the wiring system either at the battery, fuse, switch, plug, or bulb contacts; and batteries of low voltage. The importance of good contacts cannot be emphasized too strongly. A drop of ½ volt from the battery to the bulb terminal is not impossible and will result in a loss of about 6 cp. Make sure that all connections are clean and tight and, if necessary, solder them.

World Oil Situation

LESS than 20 years ago Russia produced more petroleum in a year than the United States. With the epoch of turbulence and revolution Russia sank to unimportance, while the United States rose to dominance. But we know Russia possesses enormous oil resources. We know that the present Russian Government hopes to turn these petroleum resources into financial support for its desperately weakened economic establishment. We may be sure that before many years Russia will somehow become again a power in petroleum.

To the south of us, just over the horizon of the Caribbean, we see Venezuela, with a potential production as great as was that of the United States only a few years ago. We recognize the assured possibilities of Colombia. On the other side of the world, in the great Persian-Mesopotamian area of the Middle East, we find still another factor of potential and enormous competition.

Since the war more of governmental and industrial energy and effort has been devoted to seeking out the world's resources of petroleum than to any other field of industrial enterprise. This search has so far succeeded as to bring the world's petroleum industries face to face with conditions that dwarf the significance of a few local and temporary phenomena of overproduction here in the United States.

This is a situation in which we may well invoke the serious thought and earnest cooperation of both political and industrial statesmanship. It does not concern merely a single American industry; it has vitally to do with every power-making, power-using, power-dependent interest. I believe there is vision enough, and liberality enough, among our leaders of National policy and industrial programs, to initiate measures adequate to cope with such a situation. Necessity has forced us to seek knowledge that only scientific investigation and practical research can develop. Without the knowledge of facts, no one can offer any constructive plan with the slightest hope of its adoption either by the oil industry or by the Government. Without adequate knowledge based upon provable facts, I cannot translate my opinions and ideas into actualities, nor can you. Gradually, as the industry learns the truth, one intelligent step after another will be taken, the results showing with remarkable speed once a start is made.—E. W. Clark, president of the American Petroleum Institute.

Operation and Maintenance

SECTIONS' COOPERATION SUGGESTED

Ways of Developing Operation Information for Presentation Locally Proposed

Some interesting suggestions of ways to bring out at Section meetings facts of practical value to engineers in charge of fleet operation and maintenance and to make such information available to all members of the Society through the pages of THE JOURNAL have been made by Ethelbert Favary in a preliminary report of the Subcommittee on Education, of which Mr. Favary is chairman. The object of the letter is to draw comments and suggestions from Section Chairmen and other members of the Society regarding the ideas submitted. The Subcommittee on Education is constituted as follows:

Ethelbert Favary, chairman, Box 317, Los Angeles; F. K. Glynn, Charles M. Manly, L. H. Palmer, and J. F. Winchester.

To acquaint fleet operators, maintenance men, service managers, and other factory service men with the latest improvements in methods of operation and maintenance, Mr. Favary suggests that

(1) Each Section appoint one member to serve on the National Subcommittee on Education
(2) Such appointee should preferably be experienced in preparing papers from notes submitted by, and from interviews with, practical operation and maintenance men
(3) He should interview members of the Sections, of the local service managers association and others and ask them to present papers at Section meetings or to submit notes on the conduct and problems of their work
(4) Such papers or notes would be edited and sent to the Chairman of the Subcommittee on Education
(5) The Chairman would gather from other sources information on the subjects dealt with in the papers and notes, collate all the material and forward it to the Society headquarters
(6) These papers and notes, containing the best available information from all parts of the Country, would be published in THE JOURNAL and individual copies would also be mailed to each Section member of the Subcommittee
(7) Each Section Subcommittee member would then present the material on a particular subject, or a digest of it, at a Section meeting
(8) If a number of members desire to discuss the subject they could meet at a luncheon or some evening if sufficient time is not available at the Section meeting
(9) The Subcommittee member should arrange to give talks on the subjects at meetings of the local service managers association, the fleet operators association and similar organizations, or assign this task to some other Section member
(10) The office of the Society could abstract articles on operation and maintenance as they are published in technical periodicals and send mimeograph copies to members of the Subcommittee for presentation and discussion at Section meetings

With regard to the foregoing suggestions, Mr. Favary states that at a recent joint meeting of the Board of Governors of the Southern California Section with a committee of the Los Angeles Service Managers Association and members of the Automotive Council of Los Angeles it was decided to hold joint meetings of these organizations, under the auspices of the Society Section, in October, December and February, for discussion of the following operation and maintenance subjects:

(1) Inspection of Motor-Vehicles from the Standpoint of Maintenance and Repair
(2) Front-Axle Alignment—Effect of Front Springs, Balloon Tires and Other Factors
(3) Brakes and Brake-Linings — Service, Wear, Squeaks, and Adjustment

As these subjects doubtless are of equal importance to operation and maintenance men throughout the Country, they might be discussed in the coming season in all Sections wherever possible. The information so accumulated could be classified and edited, and the result would be a valuable contribution to a more thorough understanding of the subjects.

Cooperation of the service managers through their association is believed by Mr. Favary to be advantageous, as much can be learned from them regarding their troubles and their methods of overcoming difficulties they encounter. Moreover, it would introduce them to the work of the Society, with the probability that some would avail themselves of the opportunity of becoming members.

ROAD COURTESY AND COSTS

Considerate Driving of Company Vehicles Avoids Accident Losses and Creates Good-Will

One of the intangibles that enter into the matter of motorcoach and motor-truck operating costs and profits is suggested by a statement on highway courtesy and cooperation issued by the American Automobile Association as a result of a questionnaire submitted by the Association to its club executives in nearly 1000 communities of the Country. From the large number of replies received the officers of the National organization of motor-vehicle owners have deduced that cooperation and courtesy apparently begin with the giving of signals; virtually all of the replies to the questionnaire emphasized this piont.

Financially successful motorcoach operation and motor-truck operation, in some lines of business at least, depends to some extent upon public good-will; and today's public is a motoring public. Operating executives can do much to earn good-will by insisting that drivers of their vehicles be considerate of other users of the highway as well as of the vehicles they drive. Drivers of passenger cars who are exasperated by following for miles a lumbering gasoline and oil tank-truck whose driver arrogantly holds to the middle of a narrow road are not thereby more favorably inclined to purchase the products of the company at filling stations. The same applies to other products. Such an attitude shown by truck drivers reflects a lack of consideration of the public on the part of the management of the truck-owning company.

Wide-bodied motorcoaches driven inconsiderately of the rights and convenience of motorists and pedestrians similarly create an antagonistic feeling against the operating company. And all motorists are pedestrians part of the time, and most pedestrians are motorists some of the time. Necessity or convenience may force patronage of a motorcoach line or of a company handling a certain product, despite resentment against discourteous drivers of the company's vehicles; nevertheless, good-will is a valuable asset to any enterprise. Very favorable comment was made recently in the public print upon a line of motorcoaches that has a notice painted on the rear of its vehicles reading "Blow your horn and this bus will turn out to the right."

In a Code of Courtesy issued to the company's drivers, L. S. Miller, president of the County Transportation Co.,

operating motorcoaches in Westchester County, N. Y., in Connecticut and on Long Island, says:

> Giving a few feet one way or another, or moving a motorcoach to accommodate the operator of a private car, may require a little extra effort on your part, but it may also make a good friend for yourself and for the company.

Of more direct and tangible bearing on operating costs and revenue is the likelihood of accidents resulting from failure of a driver to observe the well-known rules of the road and to give proper signals of intention to turn or to stop. Such accidents are reflected in increased repair costs and in damage suits. In discussions of operating and maintenance costs these factors usually are given very minor or no consideration. It might well be made part of the program of instruction to drivers to instil not only a willingness but a desire to be considerate of the rights and convenience of others. Courtesy pays.

Ways of cooperating on the streets and highways, which are known to virtually all drivers but are too often neglected, are listed by the American Automobile Association as follows:

(1) Use caution at all times
(2) Observe the right-of-way regulation strictly
(3) Always drive over to the right curb or right side of the road
(4) Never try to pass another vehicle until the way is clear
(5) Use the horn with discretion
(6) When surrendering the right of way at an intersecting street to a vehicle approaching from the right, stay back of the street line to let vehicles from the left pass
(7) Park with an eye to conserving space to the utmost
(8) Remember that pedestrians should be accorded courteous treatment

FLEET ACCOUNTING CLASSIFICATIONS

The Accounting Subcommittee of the Operation and Maintenance Committee has completed the preliminary draft of classifications. One of the most important undertakings of the Society's Operation and Maintenance Committee, of which R. E. Plimpton is chairman, has been the study and preparation of a classification of various items entering into operating and maintenance costs of motor-vehicle fleets including motor-trucks, motorcoaches and taxicabs. The Subcommittee has gathered a considerable mass of information and data from a large number of representative large operators as well as from motor-vehicle manufacturers, from which a preliminary classification has been prepared and discussed. Although it is too early to put forth this classification, which is now in the process of refinement, a great deal of interest in the work has been shown and it is planned to have a report of the Subcommittee presented at the National Transportation Meeting of the Society in Chicago this month, further news of which may be looked for in the November issue of THE JOURNAL.

COURSE IN HIGHWAY TRANSPORTATION

Announcement is made by the Secretary of Columbia University, New York City, of a university extension course in Commercial Highway Transportation that was inaugurated last month. The fee is $30. The course is primarily economic in character. It deals with the relation of common-carrier transportation over the highways to other means of transportation. The present and probable future participation of the motor-truck and motorcoach in common-carrier transportation, the trend in the ownership of each and the social interest in the outcome will be studied and discussed.

The following typical outline indicates the subject matter to be covered: (*a*) relation of commercial highway transportation to other means of transportation; (*b*) field of the motor-truck; (*c*) field of the motorcoach; (*d*) general evaluation of the fields of the different types of transportation, and discussion of the trend in each, inclusive of the theory of coordinated transportation.

Under division (*b*) is to be included intra-terminal trucking, including store-door delivery; intercity trucking; economic characteristics of truck transportation; container service; tractor-trailer operation; municipal traffic control and its relation to efficient trucking; railroad use of trucks, present and potential; trucking rates and their basis; operating costs and the economic field of the motor-truck.

Division (*c*) is to include the present use of the motorcoach by independent operators, traction lines and railroads in common-carrier service and for sightseeing, school and other private-carrier service; economic factors such as operating cost and convenience, which determine the degree of participation in passenger carriage; and the future field of the motorcoach.

PRIZES FOR SAFETY SUGGESTIONS

Ten cash prizes aggregating $1,000 are offered by the American Road Builders Association, City of Washington, for the best 10 ideas submitted before midnight, Nov. 15, for reducing the number of highway accidents. The amount of the first prize is $500. The awards are offered for the best workable plan that will decrease street and highway accidents. The plan may be a complete thesis covering the entire subject or a mere description of a single idea. The plan must be practical and capable of being put into operation at reasonable expense.

The winners will be announced at the annual convention and road show of the Association in Cleveland next January.

IDLE TIME A BIG COST-FACTOR

Losses at Loading and Unloading Points Add Heavily to Trucking Expense

In a discussion on motor-trucks used in the delivery of coal, at the tenth annual convention of the National Retail Coal Merchants Association, a very important point in truck operation was touched on by W. O. Hawkins, manager of coal purchases and sales, of the Consumers Co. of Chicago. He said, in part:

> In our costs the largest single item of expense is our hauling. That stands out like a sore thumb. I think that is the experience of all dealers. The consensus of opinion on the matter seems to be that the trucking is one of the largest items in our business. Some 3 years ago I made a survey to discover what our transportation costs were and why they should be, as we considered them, unusually high. It showed, in the final analysis, that the largest item and the largest amount of expense were in the yards, not on the street or at the place of delivery. Therefore we have reduced our average loading-time tremendously, and with the reduction of that came a tremendous reduction in transportation costs.

If the problem of the idle time could be solved, the costs would be reduced radically, asserts *The Retail Coalman* in commenting editorially on the subject, and the suggestion is made that the Subcommittee on Accounting of the Operation and Maintenance Committee of the Society, when analyzing costs of the delivery of coal, give consideration to the idle time of the truck in the coal-yard, the actual time in transit and the idle time at the point of delivery. Incidentally, there is more or less idle time of the truck on the streets in the business sections of the larger cities, the editorial points out. Some reduction of this can be made by good judgment in routing, and even at the point of delivery, where the retailer has little direct control of unloading conditions, the costs can be cut by using good judgment and adopting methods best suited to individual cases. It is in the yards that the retailer can make the greatest improvement, because there he has control of his equipment.

These observations, directed specifically to the coal trade,

apply to almost all trucking operations. Probably the worst examples of idle time can be seen at piers in New York City, Boston and other large marine shipping centers. So much waiting-time for opportunity to load and unload has occurred on West Street in New York City in the past that trucking firms, warehousemen and many business houses doing a large amount of shipping have found it less expensive to use horse-drawn vehicles for trucking to and from the piers. The situation could be remedied to a large extent by the installation on the piers of modern conveyors and the adoption of systematic methods of handling incoming and outgoing freight; but this is beyond control of the truck operators.

Unquestionably, the loss of time due to poor facilities for loading and unloading and to traffic congestion is one of the most serious obstacles to economical operation of trucks in large cities. It can well be taken into account in analyzing costs. The problem of remedying the situation, however, is of great magnitude. Its solution will require the cooperation of city authorities, steamship and railroad companies and all interests concerned with trucking.

Time-studies of trucking operations serve to reveal where and in what services motor-trucks can be used economically. Such studies have been made by the Port of New York Authority and by similar public bodies in Boston, Chicago and some other cities.

OPERATION'S BROAD ASPECT

Numerous Factors That Govern Success of Highway Transportation Service

Consideration already given to the subject by the Operation and Maintenance Committee shows that successful operation of motor-vehicles, including automobiles, motor-trucks, motorcoaches, and taxicabs, involves two major elements, one physical and the other legal and economic. The physical side of the problem relates to the kinds of vehicle used, the condition in which they are maintained, how they are operated, length and character of routes, and like factors. The legal and economic side relates to laws and regulations, to costs of the service rendered and to the receipts therefrom.

A multiplicity of factors affect both of these major elements. Fleet operation is not a simple matter of purchasing the right type of vehicle for the work to be done, maintaining the vehicles in good running condition, hiring the best drivers obtainable, hauling loads expeditiously, and charging prices sufficient to produce a net profit. The business of goods and passenger transportation on the highways must be adjusted to all the conditions of the highways; to the traffic on them; to legislation and regulations affecting road vehicles; to manufacturing, commercial and agricultural activities and methods; to rail and water transportation systems and practices; to customs, habits and preferences of the public; and to tariffs and fares charged for other transportation services.

Before anyone can engage in transportation with motor-vehicles, the vehicles must comply with State laws and regulations which limit size and weight, require adequate brakes, and often contain exacting headlighting requirements. In some States, notably in New Jersey, motorcoaches must conform with a long list of specific requirements. The use of trailers is hedged about with various restrictions in the different States. Taxicab rates of fare are limited and regulated in the larger cities. Various license fees and taxes, both Federal and State, must be paid for all kinds of motor-vehicle. When the vehicles are driven on the streets and roads the operator is confronted with a great multiplicity of National, State, county, and municipal restrictions that relate to commodities carried, loads, speed, signaling, lighting, use of brakes, turning, parking, and all the minutiæ of traffic regulations.

Highway engineering, construction and maintenance have a direct and large influence on successful operation. Gradients, curvature, directness, surface, width, detours, grade crossings all affect operation by limiting speed, by wear and tear on the vehicles and tires, by increasing fuel and oil consumption, or by increasing the risk of accident and damage.

Preliminary survey of the field of operation is almost a prerequisite to financially successful trucking service or motorcoach operation. Such an investigation includes estimates of traffic to be secured, character of freight or goods, routes to be traversed, length of hauls, frequency of trips, competition to be met, coordination with steam-train and electric-car schedules, location and shipping facilities of business houses and freight stations, and many related factors.

Many possibilities for large-scale operation, special equipment and cooperation with other transportation agencies present themselves for study and action. The promotion and financing of such undertakings call for executive ability of a high order.

From the foregoing brief sketch it is obvious that operation, in its broad sense, has many ramifications and is not confined to engineering in its mechanical applications but embraces at least a knowledge of current conditions in industry, economics, finance, highway work, legislation, traffic congestion, city planning, and transportation in general. While the concern of operation and maintenance managers is primarily with the physical side of the subject, they realize, perhaps subconsciously, and must bear in mind that these broad factors have a bearing on the business in which they are engaged. How far the Operation and Maintenance Committee shall go in dealing with them remains to be decided.

MOTORCOACH OPERATORS CAUTIONED

Operators of motorcoaches in Ohio were ordered recently by the Public Utilities Commission not to exceed the State speed limit of 35 m.p.h., states the *Ohio Motorist*. Violation of the order will make the operators liable to revocation of their certificates.

GRADE CROSSINGS ELIMINATED

Nearly 1800 grade crossings in this Country have been eliminated since the inauguration in 1916 of Federal aid for highway construction, either by separating railroad and highway grades or by changing the highway location, according to the *Ohio Motorist*. Nearly two-thirds of these grade crossings were avoided by relocating the roads.

Of 232,755 grade crossings in the United States that are used by motor-vehicles, only 27,161 have protection in any form. Separation of grades near populous communities is being urged, owing to the heavy week-end and holiday traffic, not only in the interest of safety but to promote continuous traffic movement.

HIGHWAY RESEARCH COMMITTEES

Reports of six highway-research committees of the Highway Research Board of the National Research Council are to be presented at the annual meeting of the Board in December. The program planned for the meeting is to be a resume of completed research, researches believed to be needed urgently in certain fields, and researches on which definite conclusions have been reached this year. The six research committees are on the Economic Theory of Highway Improvement, Structural Design of Roads, Character and Use of Road Materials, Highway Traffic Analysis, Highway Finance, and Highway Maintenance.

In addition to the foregoing, reports are to be submitted by the committees on Causes and Prevention of Highway Accidents and on Low-Cost Improved Roads.

Vol. XXI October, 1927 No. 4

The Wright Whirlwind Engine Production Methods

By Lee M. Beatty[1]

Production Meeting Paper *Illustrated with* Photographs

REMARKABLE performance of the Wright Whirlwind J-5 engine in the transatlantic and transpacific flights of Lindbergh, Chamberlin, Byrd, Maitland, Smith, Goebel, Jensen and Brock in the summer just closed makes this paper of great timely interest. Methods of manufacture and testing that result in a degree of perfection which enables an engine to function continuously at high speed at almost full load for 40 hr. without the failure of a single part even momentarily must be of prime importance to all internal-combustion-engine production-engineers who hold reliability as an ideal.

Extraordinary vigilance at every stage of production of every part is revealed by a reading of the paper to be the major factor contributing to success of the engine. Repeated tests and inspections are made of parts in process and of the engine after it is assembled. Test pieces formed integrally with castings and forgings are tested for their physical properties before and after heat-treating; crankcases, cylinders and tubes are tested by pneumatic pressure and pistons by hydraulic pressure, and parts are examined for defects after acid baths with the aid of magnifying glasses. Machining operations are performed to close limits and the work is inspected with gages and other precision instruments.

Operations on the various parts are described and the kinds of machine on which they are performed are specified. Jigs and fixtures are employed extensively for holding the work. While most of the operations are common practice, a few unusual methods are followed. About 85 machinery operations are required to complete a crankshaft, and even more to make a master connecting-rod.

Despite the many operations, tests and inspections, progressive machining and assembling methods are followed, and multiple drilling and other means are used for economical production. In brief, the procedure exemplifies the application to quantity machine production of the thorough care associated with individual master-mechanic handwork.

ONLY a short time ago the attention of the world was centered on one of the greatest individual feats in the history of mankind, the pioneer transatlantic flight of Col. Charles A. Lindbergh on May 21, 1927. This intrepid flier, when questioned about his flight, referred to the chief actors as "We," which can be interpreted as the human element and the mechanical element. The latter is, of course, the combined plane and powerplant; and of the two the powerplant is the important factor in negotiating long-distance flights.

The powerplant used in Colonel Lindbergh's flight and also in the later flights of Chamberlin, Byrd, Maitland, Smith, Goebel, Jensen and Brock, was the Wright Whirlwind air-cooled radial engine. Wherever airplanes are used this engine occupies a position of prominence and possesses such widely recognized reliability that the public has lost much of its fear of flying when the engine is used in the plane. That a consistent record of safe performance has been made is a tribute not only to the design but also to the care used in its manufacture.

The engine, known to us in the factory as the J-5, and which is referred to frequently as a marvel of engineering, was developed by the engineers of the Wright Aeronautical Corporation working in close cooperation with Com. E. E. Wilson, head of the design section of the Bureau of Aeronautics, Navy Department, City of Washington. Its simplicity and efficiency are unquestionable. Great credit is due to the engineers and designers who so ably brought this engine to its present advanced position among the aircraft engines of the world. But of equal importance is the great care taken in the manufacture of the various parts. Visitors to our plant always are impressed with the efficiency and method of handling the parts, and a frequent question asked is, Which is the most important part of the engine? To which no more fitting reply can be made than that all parts are most important; as much care is exercised in making a washer as in making a connecting-rod. The limits on dimensions are necessarily very close to make interchangeability possible.

Rigid Inspections and System Employed

One very important phase of the manufacture of the engine, of which the visitor is unaware, is the rigid inspection system employed. This is built up from long experience in the field. A trained force of specialists carefully check the parts being manufactured after every operation, using modern measuring instruments of precision. All machined surfaces must have a high-grade finish, as failures generally are traced to tool marks. A final 100-per cent inspection is made of the finished parts before they are assembled. The inspection not only covers dimensions, but the parts in their rough state are put through various strength tests. Test pieces made as part of the castings or forgings are cut off and subjected to tensile and impact tests, and also to chemical analysis to determine their fitness as outlined by exacting specifications. A chemical means of detecting defects is employed which consists of submerging the parts in their rough and semi-finished state in strong acid solutions which attack and reveal defects in the surface of the part, such as seams and cracks, very plainly. Raw materials are difficult to procure at times, due to the very special and exacting physical requirements.

A systematic procedure is followed in the manufacturing departments. The parts are made in accordance with operation or instruction sheets which are carefully prepared to assure proper coordination of manufacture.

[1] General superintendent, Wright Aeronautical Corporation, Paterson, N. J.

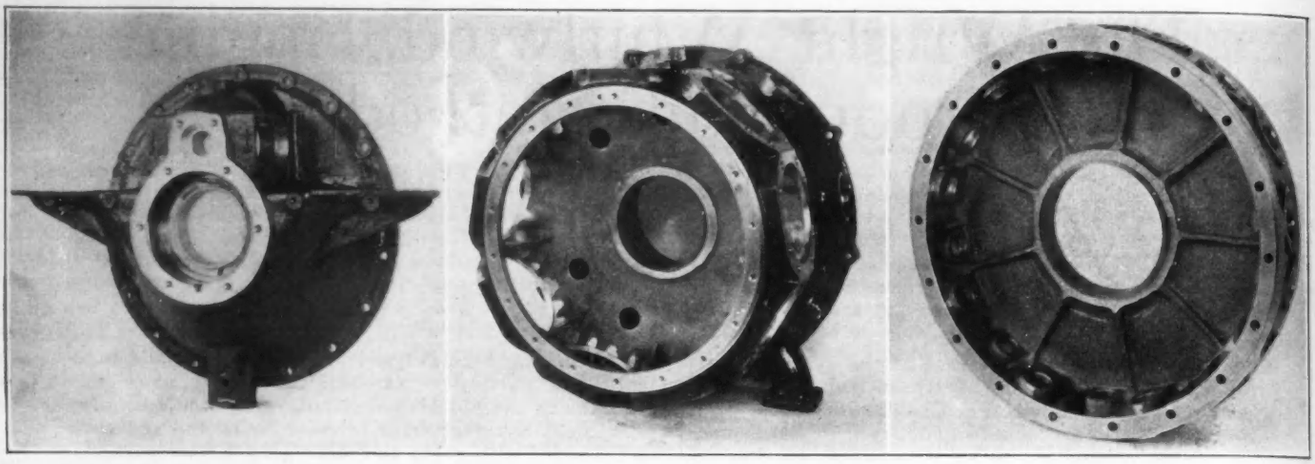


FIG. 1—CRANKCASE FRONT, MAIN AND REAR SECTIONS

These Are Aluminum-Alloy Castings and the Main Section, Shown in the Middle of the Group, Is the Largest Single Part of the Engine. It and the Rear Section, on the Right, Are Subjected to Internal Air-Pressure Tests of 70 Lb. per Sq. In. under Water. The Castings Are Heat-Treated To Refine the Granular Structure and Relieve Casting Strains, and After Immersion for 20 Min. in a Hydrochloric-Acid Bath Are Inspected for Defects. They Are Then Ready for the Machining Operations. The Eight Stud Holes in Each of the Nine Cylinder Pads Are Drilled in a Drill-Press. The Oil Passages in the Rear Sections Are Machined Successively

Special tools, such as jigs and fixtures, are used extensively to assure interchangeability and for efficiency in production. The personnel of the manufacturing department, to whom no little credit is due for the success of the Whirlwind engine, is comprised of highly skilled and efficient operators who are impressed with the importance of their work.

TESTING AND MACHINING CRANKCASE CASTING

The largest part of the engine is the crankcase main section, shown in Fig. 1, which is an aluminum-alloy casting prepared in our own foundry. Expert care is required in preparing the mold and placing the cores and chills. Before leaving the foundry the castings are thoroughly snagged and sand-blasted to remove any foreign matter. The castings are next put through a series of tests to determine their fitness, including a pressure test of the gas chambers. This is accomplished by closing the openings and applying an air pressure of 70 lb. per sq. in., which exceeds by far the ultimate pressure the chambers are expected to carry. During this test the casting is submerged in water and leaks are indicated by bubbling. Defective castings are rejected. The castings next receive a specified heat-treatment with the object of refining the grain and relieving the casting strains. They are then submerged in a hydrochloric-acid solution for about 20 min., after which a minute inspection is made for cracks, seams and other defects. At this stage the castings are ready for machining operations, which are done as nearly as possible in a progressive line-up.

Boring and facing of both ends of the crankcase are

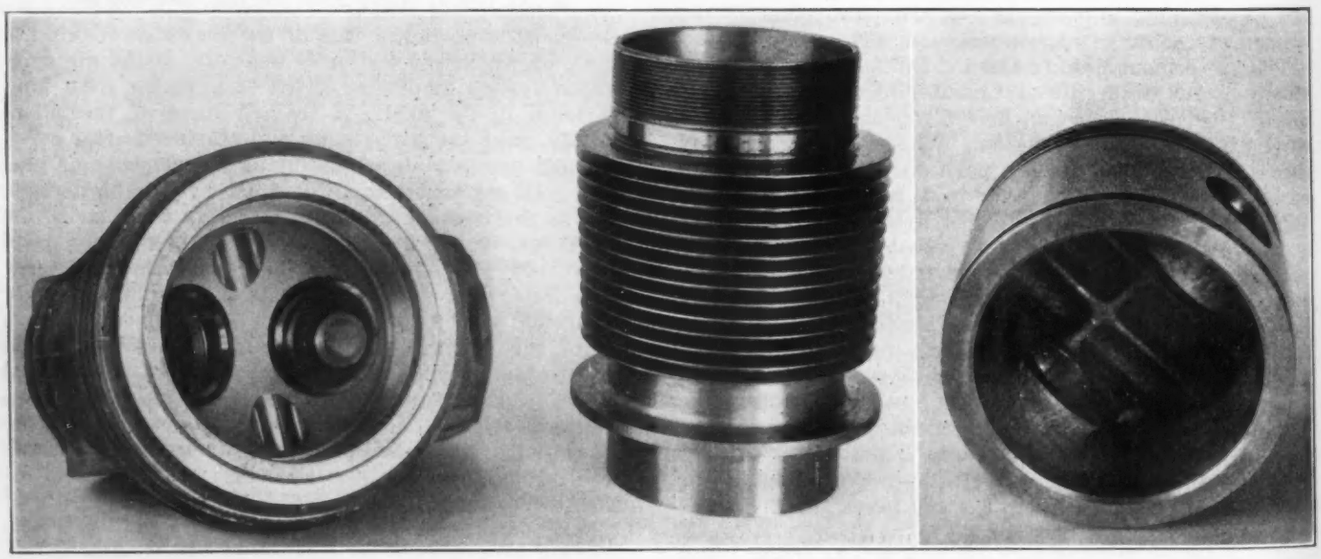


FIG. 2—CYLINDER-HEAD, CYLINDER BARREL AND PISTON

The Head, at the Left, Is an Aluminum-Alloy Casting and the Barrel, at the Center, Is Machined from a Forging of Special Steel. After the Cylinder-Head Has Been Heated to 650 Deg. Fahr., the Cold Barrel Is Screwed into It by Hand, Resulting in a Shrink Fit. The Piston Is of Y-Metal, an Aluminum Alloy, Cast in a Permanent Mold and Seasoned by Heat-Treating. The Metal Is so Hard on Cutting Tools that, after Exhaustive Research and Experimenting, the Wristpin Holes Are Now Broached Successfully with an Ordinary Round Broach Having Detachable Chromium-Plated Burnishing Buttons in the End

done on a Bullard vertical boring-mill, using standard tools. The next operation, fitting a bronze bearing-ring tightly in place, is accomplished by applying heat locally around the bearing-ring section until the metal expands sufficiently for the bearing ring to be dropped into place. This ring, in addition to the shrink fit, is staked fast with a pin. Following this operation the bearing ring is bored and the open end is faced on a vertical boring-

performed, the parts receive final inspection and are then ready for enamel applications.

Other parts handled in a similar way are the crankcase front-section, at the left in Fig. 1, the intermediate section, and rear section, at the right in Fig. 1. These parts also are aluminum-alloy sand castings and, in addition to the turning and boring operations, require a number of milling operations. The rear section is of

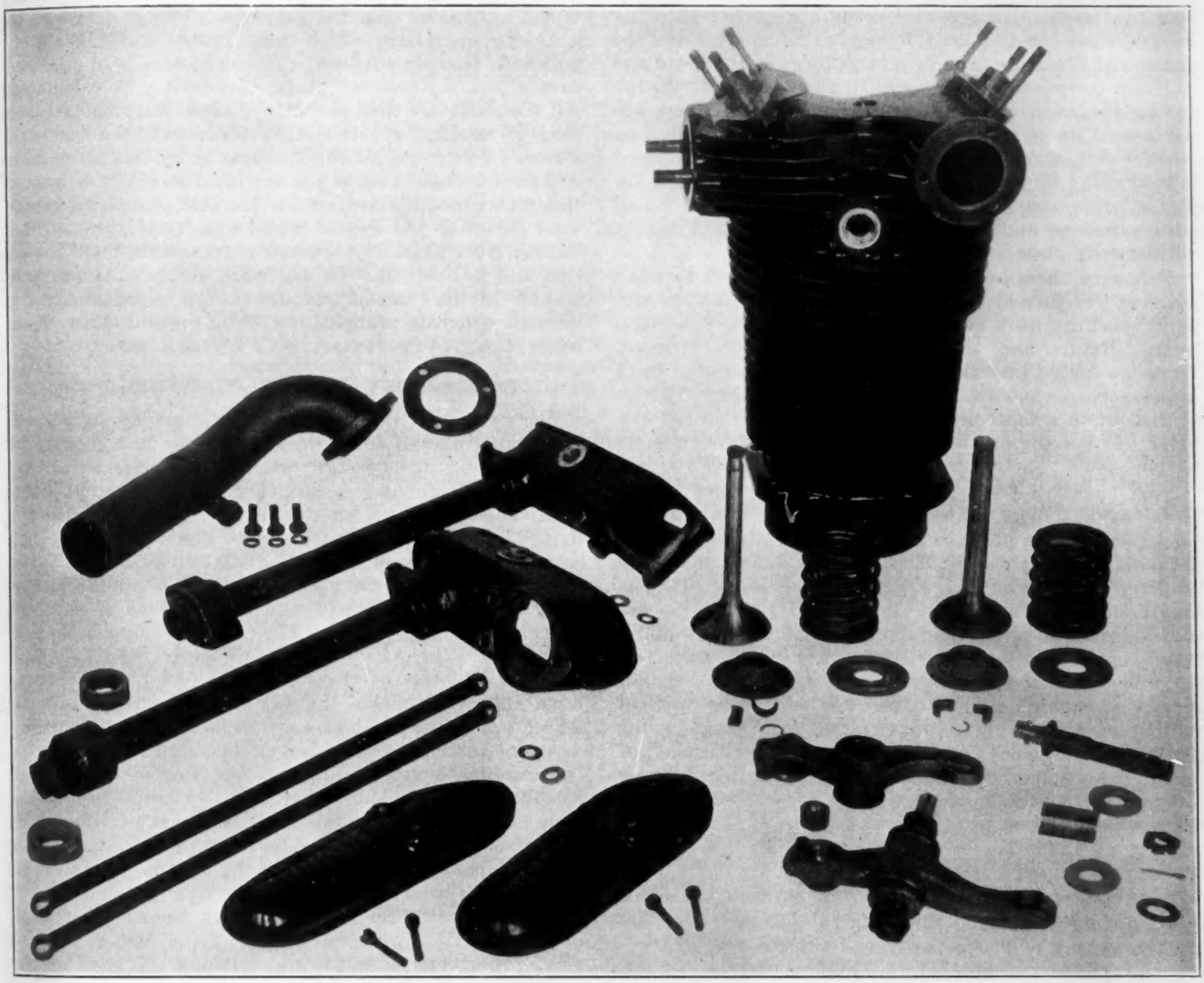


FIG. 3—CYLINDER ASSEMBLY, VALVES AND VALVE-OPERATING PARTS

The Boat-Shaped Rocker-Boxes Are Aluminum-Alloy Castings of Very Thin Section and Require Exceptional Care in Machining To Prevent Distortion and Maintain Accuracy. The Rocker-Box Covers Are Punched and Formed Complete from Sheet Aluminum. Valves and Valve Springs Are Made to the Wright Corporation's Specifications by Other Companies and Are Thoroughly Inspected and Tested. The Valve Tappets Are Turned from Bar Stock and the Tappet Guides Are Special Forgings, Hardened after Machining. Great Care and Rigid Inspection Are Exercised in Making the Valve Washers and Some of the Other Small Parts Shown

machine. The nine cylinder-flange holes, equally spaced, are then bored and faced on a horizontal boring-machine, in which the work is held on an index fixture and combination facing and boring heads are used. After this operation the nine intake-pipe bosses are bored, faced and tapped. The drilling and tapping of all other small holes, with the exception of the cylinder-stud holes in the nine cylinder pads, is accomplished on sensitive radial drill-presses. There are eight holes in a pad, and these are drilled on an upright drill-press equipped with a multiple drill-head. After a few other minor operations are

particular interest because of the numerous oil passages, which are machined successively. This part is put through an extensive pressure test to determine its fitness.

MACHINING OPERATIONS ON THE CYLINDER-HEAD

Another very interesting part is the cylinder-head, shown in Fig. 2. We are proud of the efficient manner in which this is produced. It is a machine-molded aluminum-alloy casting, produced in our foundry. The castings are cleaned thoroughly and sand-blasted, after

which they are tested for defects under 70-lb. air pressure in the same way as the crankcase main-section. The castings are then heat-treated. The first machine operation is solely for the purpose of establishing positive location points for the succeeding operation. It consists of chucking on the inside diameter of the open end, turning the first fin to a close-dimension diameter, and drilling to a given depth and squaring-up a ⅜-in.-diameter hole in the dome end of the cylinder. The prime object of this small bottom hole is to provide a stop on the boring fixture used on the next operation of machining the dome, and it assures equal wall thickness at the dome and uniform compression chambers in the cylinders. Rough facing the open end and rough forming the dome are performed on a heavy upright drill using combination tools. Finishing is done on Jones & Lamson turret lathes, using tools of special design. This operation includes boring and threading the cylinder-bore, since all bores, recesses and faces must be concentric and square within very close limits.

Following these operations, the cylinder is put through a severe pressure-test to determine its fitness before any more machine work is done. It is located in a special testing fixture and all openings are securely plugged. Water is forced into the cylinder by a force pump until a pressure of 600 lb. per sq. in. is reached. This is equivalent to a total pressure of several tons in the cylinder. If leaking or sweating occurs, the cylinder is rejected.

Next comes the rough and finish facing and boring of the exhaust port, which is held to close limits and is used as a locating point on all future operations. Special fixtures and combination boring and facing tools are used on an upright drill-press. Succeeding operations are the boring, facing and tapping of the intake-port holes, also on an upright drill-press; drilling and tapping two spark-plug insert holes, which are counterbored on the inner side of the cylinder with special back-facing counterbores; milling the rocker-box pads on a vertical milling-machine using a special index fixture and boring the valve-guide holes and the seats for the valve-seat inserts. An anchorage is formed for the latter. These last two are separate operations for which special index fixtures are used on upright drill-presses.

Cylinders Assembled with Shrink Fits

The cylinders are then placed in a furnace heated to 650 deg. fahr. to expand the castings sufficiently to permit the placing of bronze valve-seat inserts. After cooling, the cylinders are placed on a holding fixture and the lower part of the valve-seat insert is spun into the anchorage previously formed. The valve seats are next formed to a gage to assure uniform seats. Following this, the drilling and tapping of all small holes is done on sensitive drill-presses. Quick-change collets and chucks are used through all operations involving the use of several tools on one-spindle machines. The parts are now carefully inspected, after which the cylinder barrel is screwed into the cylinder-head. In this operation the cylinder-head is first heated in a gas furnace to 650 deg. fahr. to expand it sufficiently, then is placed on an assembly stand and the cylinder barrel is quickly screwed into place by hand. The intake-pipe flange is also screwed in place. The screwing together of these parts requires but a fraction of a minute. The cylinder-head and sleeve assembly, as the part is now known, is put through a final pressure-test of 600 lb. per. sq. in.

The next machining operation consists of drilling eight holes in the cylinder-barrel flange on a multiple-spindle drill-press, and following this the flanges are milled with slotting saws in a gang set-up. All other small holes are now drilled and the spark-plug inserts are screwed and anchored in place; and finally the valve guides are pressed into position. The complete assembly is then sprayed all over, except the finished surfaces, with black enamel and baked in standard ovens.

The cylinder assembly is now ready for grinding, which is done on internal grinders. This is followed by a honing operation, which must result in an absolutely polished bearing-surface. All cylinders are checked carefully and the percentage of bearing is calculated. All the studs are then screwed in place, care being taken that at no time are the studs subjected to a torsional stress. To determine the freedom from this stress, the rocker-box studs have a line scribed the entire length of the unthreaded portion, and if the stud is twisted in the least this does not appear as an absolutely vertical line. The cylinder assembly thereupon receives a final inspection and is ready for the engine assembly. All parts in transit in the various manufacturing departments are kept in separate compartments to prevent them from being damaged by contact with adjacent parts.

Cylinder Barrels Machined from Steel Forgings

The cylinder barrel, shown at the center in Fig. 2, comprising part of the cylinder assembly is a forging of special steel. It is rough machined all over in an annealed condition and is put through a series of heat-treatments. A check on the hardness is made with the Brinell hardness testing-machine. The barrels are then bored and faced on double-spindle turret-lathes. The outside diameters are also turned on a similar lathe, using expansion arbors to hold the work. The next operation consists of turning 17 fins on a duomatic heavy-duty lathe. These have a depth of more than ½ in. and are 1/64 in. wide at the top. Two tool blocks operate simultaneously and cut the fins complete from the solid barrel, after which the fins are tapered off with a separate tool fastened to the top of one of the tool blocks. The machine is stopped only to remove the work, which is held on an expansion arbor, and to change tool blocks when the tools become dull. An extra set of tool blocks is reconditioned while one set is in operation, thereby avoiding delay in the operation of the machines. The threads are cut on a thread miller to fit gages and are cut 0.015 in. oversize for a shrink fit in the cylinder-head. Other operations are the facing of the end to a close dimension from the flange and forming the back of the flange. The part is carefully inspected before assembling to the cylinder-head.

Nine exhaust and nine intake rocker-boxes for each engine are cast from aluminum alloy in permanent molds. They are boat shaped, as may be seen in Fig. 3, are of very thin section, and require exceptional care in machining to prevent distortion and to maintain the necessary accuracy. A number of drilling and milling operations are performed, using jigs and fixtures on all operations. High-speed sensitive drill-presses are used on all the drilling operations, and multiple-cutting and continuous-milling methods are employed in the various milling operations. Disc grinders are used to machine the cover face. Finally, the parts are enameled on the outside and baked in ovens. The rocker-box covers are punched and formed complete from sheet aluminum on a punch press.

Many small aluminum castings, such as oil-pump and

fuel-pump parts, shown in Fig. 4, and bearing retainers are permanent-mold castings and are made in large quantities, using the most modern foundry methods. These castings are heat-treated to refine their structure, and specimens of every mold or lot are put through tensile, impact and other tests to check their physical characteristics, which must come within specified limits set by our engineering department. Exacting laboratory tests are made to determine their molecular structure. No effort is spared to make our castings the best that can be produced.

Wristpin Holes Broached in Y-Metal Pistons

The pistons used in the Whirlwind and all other Wright engines are composed of an aluminum alloy, known to us as Y-metal. They are cast in permanent molds and seemingly have an excessive amount of metal to be removed by machining, but this has been found necessary to secure castings of uniform density. The castings are seasoned by special heat-treatments. One of these pistons is shown at the right in Fig. 2.

As the metal composing the pistons is rather trying on the cutting tools, it was necessary to make an exhaustive research into cutting steels and do considerable experimenting before we were able to obtain satisfactory results. As an illustration, prior to adopting this metal for our pistons, we were boring the wristpin holes with a diamond inserted in a boring bar, which gave excellent results. However, on the new metal we could not get smooth true holes with this tool. Various high-speed and carbon steels were also tried without success. Finally we found that chromium-plated tools gave excellent results. Of late we have successfully broached the wristpin hole, and this method has greatly increased our production on this operation. An ordinary round broach is used which has detachable chromium-plated burnishing buttons on the end.

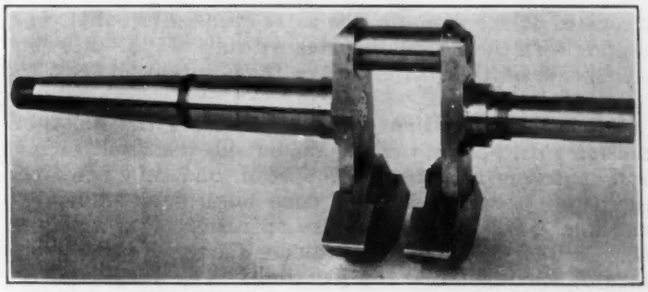


Fig. 5—Assembled Crankshaft with Balance Weights Attached

Eighty-five Machining Operations Are Required To Complete This Crankshaft, Which Is Forged from Special Steel. They Include Turning, Milling, Gun Finishing and Grinding. Two Shafts Are Worked upon at the Same Time in Nearly Every Operation. The Balance Weights Are Attached and Turned in a Lathe until the Exacting Balance Requirements Are Met. The Weights Are Assembled Segments of Bronze and Steel

Excessive metal is removed from the pistons in the first operations, and following this they are heat-treated to refine the structure. The second machine operation consists of boring the skirt or open end to a close dimension for use on following machine operations, in which the piston is held on a special chuck locating the inside

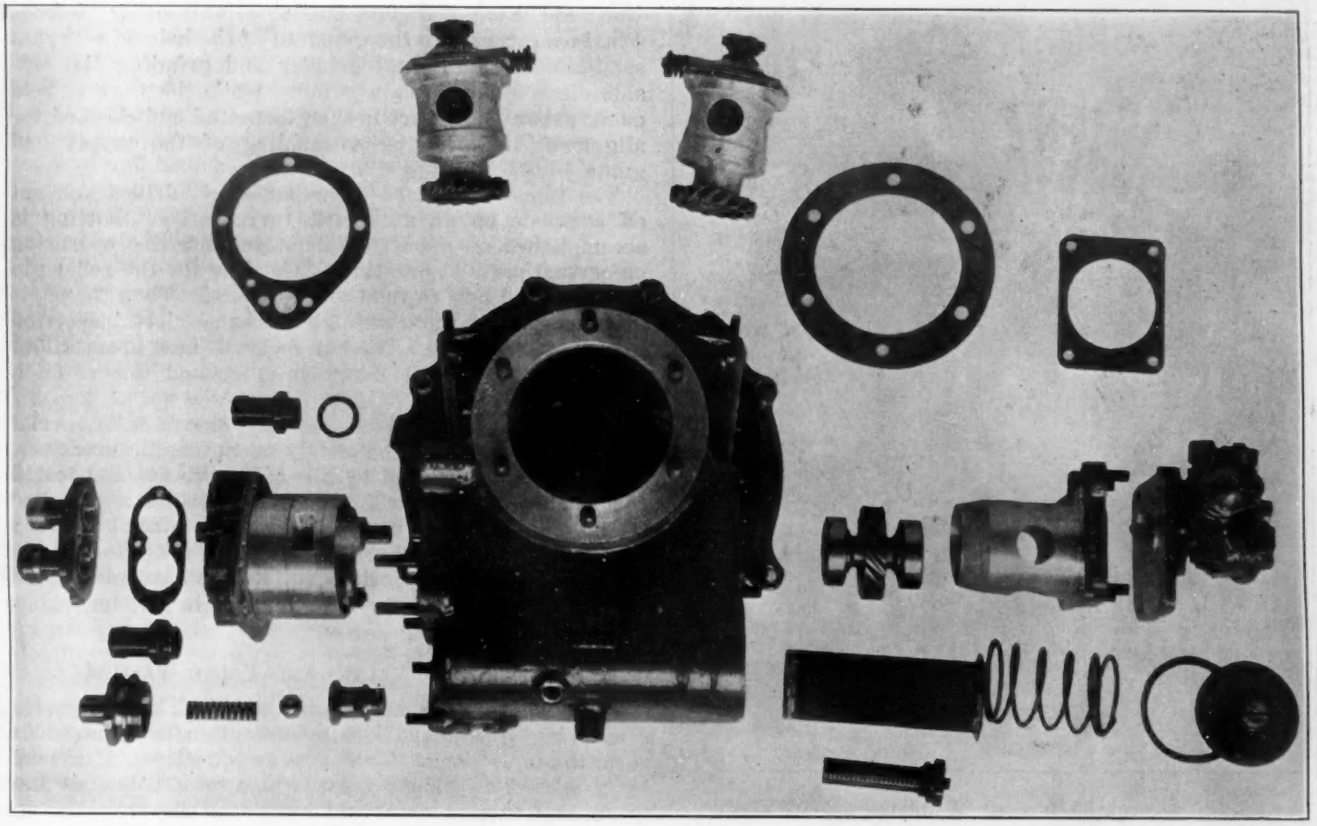


Fig. 4—Dismantled Parts of Oil-Pump, Fuel-Pump and Synchronizer Assembly

Many Small Aluminum Castings for the Oil and Fuel Pumps, Synchronizers and Other Parts Are Produced in Large Quantities in Permanent Molds by Modern Foundry Methods. They Are Heat-Treated To Refine Their Structure and Specimens of Every Heat Are Given Tensile-Strength, Impact and Other Tests

diameter of the piston. The skirt opening is bored concentric with the inside diameter within 1/64 in. Ribs on the inside of the pistons make them rather difficult to hold.

Succeeding operations consist of drilling the wristpin hole on a drill-press, turning the outside diameter, facing and centering the boss on the head, and rough-cutting the ring grooves, which is done on a semi-automatic machine. Following this last operation, the wristpin hole is redrilled and the outside diameters are finish turned, leaving stock for grinding. The ring grooves are finish turned and burnished by rolling, after which the wristpin hole is rough bored on a special horizontal machine. The pistons are now tested for leaks, using hydraulic pressure. The wristpin hole is next bored or broached to size, and then the outside diameters are ground. After finish-facing the head and removing the center or working boss, the pistons are inspected and weighed carefully. The weight and tolerance are very close and are brought within the requirements by reboring the skirt. Kerosene is used as a cutting lubricant on all finishing operations. During transit between the machining operations the pistons are kept in individual containers.

Piston-pins are made from special steel tubing bored and cut to length in automatic machines. Following this they are normalized, then rebored in semi-automatic chucking machines, and then hardened. Electrically controlled gas furnaces are used and the parts are quenched in a vertical position to prevent warping. The parts are next submerged for about 20 min. in a 50-per cent hydrochloric-acid solution which attacks defects much more rapidly than sound surfaces, thereby enabling the inspector to detect an unsound wristpin readily. Thereafter the pins are ground on centerless grinders which make five passes, removing less stock at each successive pass. Following operations consist of grinding the open ends on an internal grinder to receive the wristpin plug and grinding both ends square on a surface grinder. The final operation is the lapping of the outside diameter to size within a limit of 0.0002 in. on a production lapping-machine. Lastly, the parts are inspected for size and packed individually in waxed paper.

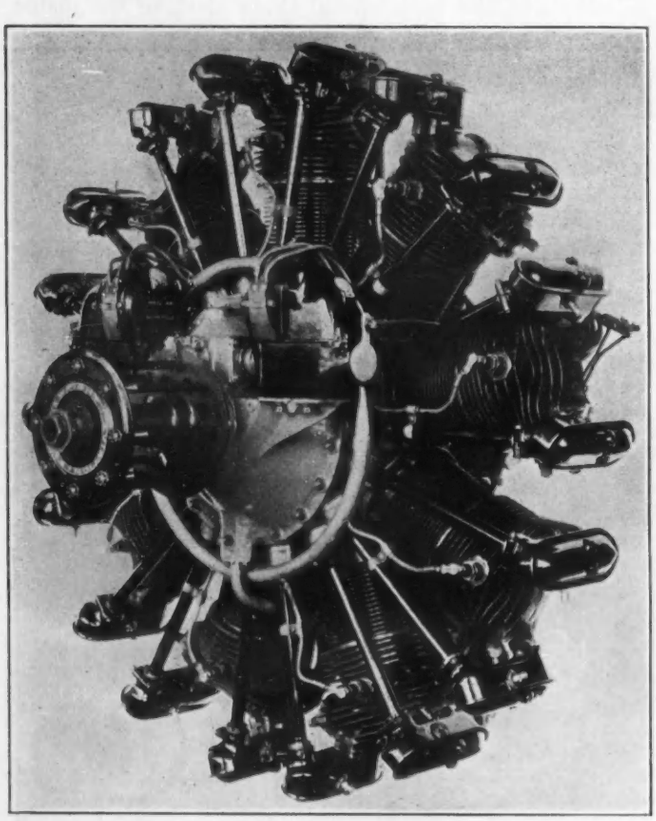


FIG. 6—ASSEMBLED WRIGHT WHIRLWIND J-5 ENGINE

This View Shows the Propeller Hub and Hub-Bolts at the Front. Behind and Above the Hub on Either Side Are the Two Magnetos. At the Head of the Nine Radial Air-Cooled Cylinders Are the Rocker-Boxes, from Which Rocker Rods Extend into the Crankcase for Operation by the Cam Ring

OPERATIONS ON VALVE TAPPETS AND GUIDES

The valve-tappet guides are special steel forgings, which are cleaned to remove scale and inspected before beginning machine operations. The parts are chucked in turret lathes, in which the flange is rough turned and drilled and reamed through, followed by an operation of turning the outside diameter and facing the flange, the part being held on a shoulder arbor and using combination tool-blocks so that all the diameters will be turned at one time. Then the parts are carburized and a ball is pushed through the hole to intensify the metal at the hole. Approximately 0.005 in. of metal is left to be removed in grinding the hole. Again the parts are turned on an arbor to remove areas of carburized surface which are to be left soft. The two holes in the flange are drilled on a multiple drill-press. The guide slot for the roller is milled next, using multiple fixtures having a gang arbor during this operation on a horizontal milling-machine. At this stage the guides are hardened and sand-blasted to remove the scale, then immersed in a chemical solution and examined for fractures and other defects. Final operations are the grinding of the hole on a Bryant semi-automatic internal grinder and grinding the outside diameter on a plain grinder while the work is held on an arbor. The part is then inspected and checked for alignment, followed by assembling of the tappet and guide.

The tappet is turned from bar stock, drilled and cut off complete on an automatic turret-lathe. Slotting is accomplished on a horizontal milling-machine operating on several parts at one time. The hole for the roller pin is drilled and held in relation to the slot. Then the parts are hardened and put through the same rigid inspection as the tappet guides. The ball socket is next pressed into place and the outside diameter is ground to size on a centerless grinder.

The ball socket and push-rod balls are made of special steel and are formed completely on automatic machines. The parts are hardened by a cyanide process and tested for hardness on a Rockwell machine using a diamond cone. The hardness range is from 64 minimum to 68 maximum. Next they are immersed in a nitric-acid solution and examined for defects. Before hardening these parts, the ball ends are ground on a plain grinder, using a special ball-grinding device.

TREATMENT OF VALVES AND VALVE WASHERS

Valve washers are made from bar stock on automatic machines. A second chucking operation is required to form the taper holes. The parts are effectively hardened by a special cyanide process which does not scale the parts. Great care and rigid inspection are exercised in making these parts, as they are called upon to perform a very important function in the engine. Elaborate gaging devices are used in the inspection. Of equal importance are the valve lock-washers, which also are made

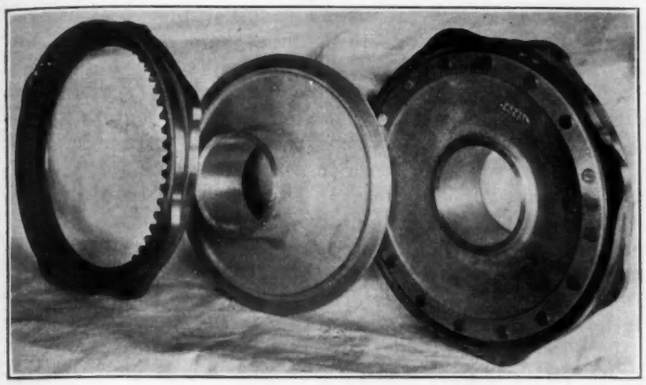


FIG. 7—VALVE CAM-RING, ALUMINUM HUB AND ASSEMBLY

The Cam Ring, with Its Internal Gear, Is Forged from Steel, Normalized, and Rough Finished. The Teeth and Cams Are Cut on a Gear-Shaper. The Hub, Cast of Aluminum, Is Fitted into and Riveted to the Cam Ring, and a Bearing Bushing Is Pressed into the Hub. Finally, the Cams Are Ground and Then Checked on a Special Dial-Indicator Type of Testing-Machine

of special steel on automatic machines and require a second chucking operation. Very exacting demands are made on this part. An operation of splitting in halves is performed on a hand miller, after which the parts are hardened by the cyanide process.

Valve springs are made by spring specialists to our specifications. Careful inspection is made with elaborate electrical testing equipment. The intake-valve guide is made of a special bronze-alloy bar stock and is made completely on an automatic machine. The outside is ground on an arbor. The exhaust-valve guide is made from tungsten-steel bar stock roughed out on automatics, then normalized and sand-blasted. Following this, a ball is forced through to reduce the grinding allowance in the hole to approximately 0.006 in. Then the parts are hardened and tested. A semi-automatic internal grinder is used for grinding the hole, which is 11/16 in. in diameter and about 2½ in. long. The outside diameter is next ground while the parts are held on an arbor.

The valves are made by a reliable company to specifications prepared by us and are put through severe tests which we specify. They are inspected for defects by chemical and metallurgical means at our factory. The exhaust valves receive additional attention as follows: They are dipped in gasoline and then in a boiling caustic-soda solution to remove oil; are immersed head down in a bath containing commercially pure potassium nitrate at a temperature of 700 to 900 deg. fahr. until all bubbling from the interior ceases; are raised above the liquid and a ¼-in.-diameter ejector-rod, which has been preheated to the temperature of the bath, is pushed down until it strikes the bottom of the hole in the valve; the ejector rod is removed and the valves are taken from the bath and allowed to cool; valve-stem plugs are next driven into the valve stem with an arbor press; the valves are then washed and placed in a furnace and heated to between 700 and 750 deg. fahr. for ½ hr.; after cooling they are inspected for leaks, dipped into a 50-per cent hydrochloric-acid solution at 180 deg. fahr.; and finally they are washed, inspected and placed in finished stores. Lapping of the valve seat is done when assembling.

EIGHTY-FIVE OPERATIONS ON THE CRANKSHAFT

The crankshaft, shown in Fig. 5, is a forging of special steel, and a test piece is forged as part of every shaft. This test piece is cut off and corresponding numbers are stamped on the shaft and the test piece, then the test piece is put through a series of tests to check the physical requirements, and a complete record is kept of every performance. The shafts are rough machined all over, then placed in a 50-per cent hydrochloric-acid solution for about 30 min., after which they are inspected for defects. The shafts are finally finish machined and ground all over.

About 85 operations are necessary to complete a crankshaft. These consist of turning, milling, gun drilling and grinding. In nearly every operation two shafts are worked upon at one time. In making these shafts considerable care is exercised to maintain symmetry, which is very essential to perfect balance in the final assembly. The balance weight is attached and is turned on a lathe until exacting balance requirements, which are checked on a high-speed balancing machine, are obtained. The balance weight is composed of a bronze and steel assembly in the shape of a segment and is attached to the shaft by special bolts and screws.

MACHINING OF HUBS AND VALVE ROCKERS

Propeller hubs and flanges, seen on the front of the engine in Fig. 6, are of varied design to suit customers' requirements, but they are invariably steel forgings rough machined, heat-treated and finish machined all

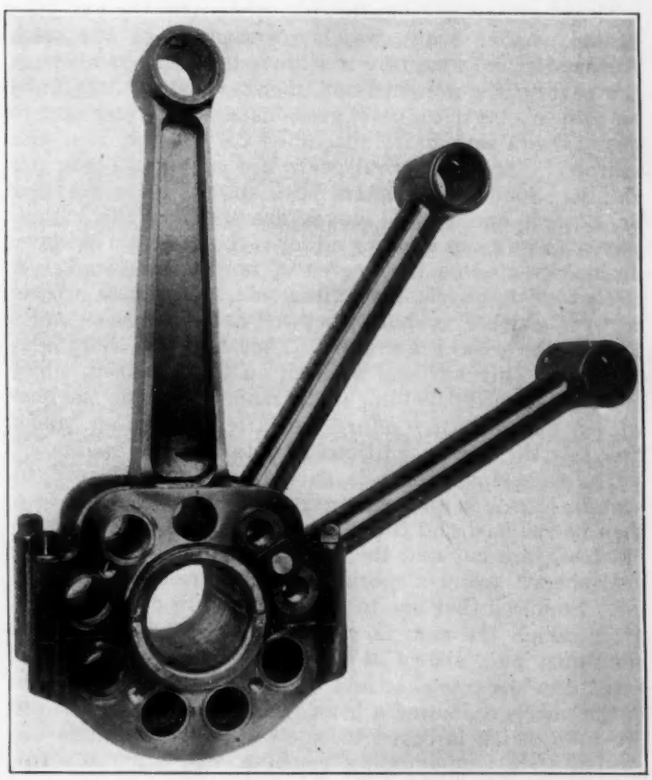


FIG. 8—MASTER CONNECTING-ROD AND TWO ARTICULATING CONNECTING-RODS

Eighty-Seven Machine Operations Are Needed on One Master Connecting-Rod, Which Is Forged from S.A.E. 3140 Steel and, After Rough Machining, Is Heat-Treated First in a Gas Oven and Then Drawn in a Lead Pot. Hardness Requirements Are Checked on a Brinell Machine Applying a Pressure of 6600 Lb. Impact and Tensile-Strength Tests Are Also Applied. Then the Rod Is Finish-Machined and Ground in a Progressive Line-Up of Machine-Tools, a Jig and Fixture Being Used throughout All Operations. Finally It Is Weighed and the Weight Is Etched on the Rod for Reference in the Final Balancing Operation

over. The propeller-hub bolts are finished complete on automatic machines. The valve rockers are special steel forgings of unusual shape and are given severe tests to determine their fitness. They are snagged to remove the die flash and rough polished all over. Following this they are placed in a strong acid solution and carefully examined for defects.

The first machining operation consists of straddle milling the hubs. Then the hole in the hub is drilled and reamed. These parts are unusually tenacious and require specially treated tools to meet production requirements. The roller slot is next milled, followed by drilling and reaming the roller-pin hole. The adjusting-screw hole is drilled and tapped on a drill-press, using a special chucking fixture. The binder-screw hole is drilled and tapped as a final machining operation. After the parts are inspected, a bushing of special bearing-metal is pressed into the hub hole. This bushing is broached to size and then faced on a turret lathe, using a quick-acting expansion adapter to hold the work in place.

The rocker roller and pin are made complete on automatic machines, carburized and hardened, then ground within specified limits. Prior to hardening the roller, a ball is forced through the hole in the roller to intensify the metal around the hole.

Production of Gears and Cam Ring

Gears are made from forged blanks with the exception of the smaller gears, which are made from bar stock. Automatic and chucking machines are used extensively, the parts being roughed out, then normalized and finish machined. Teeth on bevel gears usually are rough cut on gear-cutters and finish machined on Gleason gear-generators. Spur and spiral gears are cut on hobbing machines. Some of the gears have splined holes broached or slotted, and special gages are used to check these parts. The gears are then either carburized and hardened or heat-treated to the degree of hardness desired, consistent with physical requirements. Hardness of the parts is checked by both Rockwell and scleroscope tests. Finally the gears are ground. They are then thoroughly checked. This includes a check on the backlash, which must not exceed 0.006 in., and is made by rolling the gear with a master gear, before and after hardening, under precisely the same conditions as obtain in the engine.

The cam ring, which is part of an internal gear, as seen in Fig. 7, is a steel forging rough machined all over, then normalized and the parts finish turned. The internal teeth are cut and the cams rough cut on a Fellows gear-shaper, using a special index fixture and form cutter. Surfaces that are to be left soft are copper-plated, after which the cam is carburized and hardened. An aluminum hub, shown at the center in Fig. 7, is next fitted into the cam gear and riveted fast, as on the right in the photograph, and a bearing bushing is pressed into the hub, which is bored to size. Finally, the cams are ground on a cam-grinding machine, and the cams and gear are checked under conditions like those existing in the engine, using a dial-indicator testing-machine of our own design.

Connecting-Rod Tests and Operations

One master and eight articulating connecting-rods used in each engine are made of forgings from S.A.E. 3140 Steel. A test piece forged integrally with each rod is cut off, and rod and test piece are stamped with corresponding serial numbers, after which the test piece is examined and the rod is given a visual inspection. Then the rod is rough machined all over to within $\frac{1}{8}$ in. of the finished size. Meantime the test pieces also have been machined to specified dimensions and these are heat-treated together with the corresponding rods to obtain the proper hardness consistent with structural refinements. The rods are heated to 1500 deg. fahr. for 3 hr. in automatically controlled gas furnaces, then quenched in oil and drawn in a lead pot at 800 deg. fahr. and quenched in hot water. The hardness requirements of from 280 to 320 Brinell are checked on a Brinell testing machine in which a pressure of 3000 kg. (6600 lb.) is applied. The test pieces are examined again and subjected to a series of tests to determine their physical characteristics. There tests include an Izod impact-test at a minimum value of 45 ft-lb. and a tensile test to determine the elongation and yield point. A minimum elongation of 17 per cent at an elastic limit of 105,000 lb. per sq. in. is required. Following these tests, the rods are sand-blasted to remove scale and are placed in a 20-per cent acid solution for 20 min. Adhering sand is then blown off with a jet of live steam and defects in the rods are searched for with a powerful magnifying glass. The rods are then finish machined and ground on modern machine-tools used in a progressive line-up. Jigs and fixtures are used throughout all operations. Finally the rods are polished and inspected for dimensions and alignment. Eighty-seven machinery operations are required to make one master connecting-rod.

Bronze bushings are pressed into the piston end of the rods and also into the knuckle-pin end of the articulating rods, which are bored to within 0.001 in. limit in size and 0.005 in. parallelism in 10 in. A steel-backed Kelmet bearing is fitted into the crankpin end of the master rod. To assist inspection the rods are highly polished. They are also weighed and the weight is etched in a designated place for reference in the final balancing operation.

Connecting-rod bolts are rough machined on an automatic machine to within 1/32 in. of the finished size and are then heat-treated and placed in a 50-per cent hydrochloric-acid solution, after which they are examined for defects with a magnifying glass. The parts are then finish machined and ground.

All studs and nuts are made on automatic machines with the exception of the threads which, in the nuts, are rough and finish tapped on a nut tapper, and on the studs are cut on threading machines. Gages and the familiar comparator are used for checking the threads. Our threads, while standard in form, are held to certain minor and major diameters, determined by extensive experiments carried on over a long period, to increase their efficiency.

Exposed studs, nuts and other steel parts subject to corrosion are treated with parcolac, an effective anti-rust preparation. Some of the exposed parts are made of stainless steel.

Tubes used on the engine usually are made from seamless steel, and copper tubes are lined internally with steel tubing to the required form to reinforce them. A special process is used for bending the tubes. Flanges are welded on and the tube and flange assembly is tested under pressure greatly exceeding the pressure to which they will be subjected under operating conditions.

Assembling and Testing the Engine

A very recent addition to the engine is the carbureter air-heater, which consists of two aluminum castings, a steel tube and a bronze lever. Machining operations on this consist of straddle-milling and drilling and tapping

on sensitive drill-presses. The parts are then inspected and assembled.

The final engine assembly is made under expert supervision, and modern assembly tools and holding devices are used. Various sub-assemblies are made progressively. The parts are cleaned scrupulously with gasoline and compressed air. After the engine is assembled it is inspected and timed with special timing devices. It is then run-in with a belt and pulley driven by overhead shafting at slow speed for 4 hr. Next it is placed on a test stand and coupled to a dynamo in an elaborately equipped testing department, where the running test begins in a closed wind tunnel. Windows are provided in the sides of the tunnel for observation. Experts are in charge of all tests, and complete records are kept of every engine. The production "running-in test" covers a continuous period of 5 hr., the last 2 hr. at nine-tenths engine-load.

Following this test the engine is dismantled, all its parts are inspected, and it is then reassembled. Again the engine is placed on the dynamometer test-stand and is operated for ½-hr. periods at "running-in speed," at nine-tenths load, and at the rated load, and finally is given a 15-min. idling test. A record is kept of the fuel and oil consumption, oil pressure and temperature at both the front and rear of the engine. The engine must develop the guaranteed 200-hp. rating at 1800 r. p. m.

Once more the engine is gone over carefully, the nuts and bolts are tightened, and a visual inspection is made of all wiring, tubes, and other attachments.

For shipment, the engine is crated in a specially constructed box. A kit of field service-tools is included with each engine. A service department, the personnel of which consists of engine experts and engineers, is at all times ready to serve customers and the public in general.

Cracking Processes

THE first cracking-process to come into any general use was the well-known Burton process, in which the oil is heated to about 750 deg. fahr. in a horizontal boiler or still, from the top of which an inclined run-back pipe extends to the condenser. A pressure of 75 to 85 lb. is maintained throughout the system, and the crude gasoline is condensed under this pressure. As the run-back is exposed to the air, the less-volatile material condenses in the run-back and returns to the still for further treatment. Fifty per cent or more of the still charge is thus converted into gasoline.

The Burton process underwent numerous modifications and is now largely supplanted by processes of other types operating at much higher pressures. Foremost among these are those of Cross, Holmes-Manley and Dubbs.

In the Cross process the oil is brought to cracking temperature during its rapid passage through a heating coil and is then delivered to an insulated reaction-chamber, where the conversion of the oil to gasoline takes place under heavy pressure. Separation of the gasoline by distillation is effected only after the converted oil has issued from the reaction chamber.

The Holmes-Manley process operates at much lower pressures, and further differs from that of Cross in that the oil, after passage through heating coils, is delivered to vertical stills, the walls of which are heated, while the gasoline distills off as fast as it is formed.

Still lower pressures are employed in the Dubbs process, in which the oil, after leaving the heating coils, is discharged into a large insulated chamber, from which the lighter vapors constantly distill, while the residuum of heavy oils is continuously drawn off.

In the more recently developed vapor-phase processes much higher temperatures are employed, and the oil issues as vapor from the heating coils into a reaction chamber, through which the vapors pass at atmospheric or slightly higher pressure. By a regulated system of condensation the gasoline formed is separated from the heavier "cycle-stock" which is re-run.

Vapor-phase gasoline is remarkable for the large proportion of unsaturated hydrocarbons it contains, and to which it owes its notable antiknock properties. It is more expensive to manufacture than liquid-phase gasoline, and its field is probably limited to those refineries which wish to supplement their regular production by a blending agent that will put their motor fuel into the premium class.

During vapor-phase cracking a considerable portion of the oil is converted into gas, and the process derives much added interest from the fact that methods have been developed for the production, from this gas, of many different alcohols, as well as special solvents for the nitrocellulose so largely used in lacquers and automobile finishes.—Industrial Bulletin of Arthur D. Little, Inc.

Agricultural Outlook Encouraging

THE strongest basis for the general confidence that has been so clearly demonstrated with regard to the business outlook for the next few months is the agricultural situation, which is usually the outstanding influence bearing on near-term trade prospects at this time of year. After an inauspicious start, most of the leading crops improved greatly during the summer; and, with prices of the principal farm commodities at comparatively favorable levels, there is reason to hope that agricultural income will be the largest in several years. Eugene Meyer, commissioner of the Federal Farm Loan Board, recently made public the results of a survey indicating that returns to farmers from the sale of crops and livestock would be larger this year than in 1926 by at least $1,000,000,000.

Although there is time for both crop yields and farm prices to vary widely from summer estimates before the harvesting is completed and the bulk of the agricultural production has been marketed, losses from crop shortages will tend to be offset by higher prices; so it may be considered fairly certain that the season will be one of distinct progress for the majority of farmers.

Particularly in the Northwest, where agricultural depression has been exceptionally acute and persistent, conditions seem more encouraging than at any other time since the post-war deflation. In addition to relieving distress among farmers, this improvement will directly benefit banks and railroads in the Northwest, together with mail-order houses and manufacturers of agricultural machinery and fertilizers; while its effects will be felt indirectly by trade in general throughout the Country.—*Guaranty Survey.*

The Relation of Metallurgy to Production

By J. M. WATSON[1]

PRODUCTION MEETING PAPER *Illustrated with* DRAWING AND PHOTOGRAPH

A FEW years ago the metallurgical department was considered only as an overhead expense and a novelty. Now it has a definite place in a manufacturing organization and recognized relations with other departments.

It helps the engineering department in design and in selection of materials; the purchasing department by visiting sources of supply; the production department by inspecting incoming material, overseeing heat-treatment and securing material of a sort and condition suitable for machining; the sales department by means of sales talks, giving information to dealers and distributors; and the service department by inspecting incoming service-material, studying returned parts, and guarding against trouble due to pirate parts. It thus cooperates with other departments of the organization and consequently exerts a strong influence on the reputation of the company.

IN one of the engineering trade papers, the quotation[2] printed below recently appeared. It is to be hoped that this does not correctly state the attitude of the metallurgist toward production.

> There was a time not so far back in the history of the designing engineer, when he got out his slip-stick, log-books, etc., and designed his product without very much regard to shop methods, shop facilities or commercial stock practices. He felt he was an engineer who designed something, which from a purely scientific viewpoint was the ideal. Today he analyzes each phase of his design in terms of shop operations and equipment and of commercial material and sizes. His dimensions are expressed in the manner most applicable for direct shop production.
>
> The metallurgist is sometimes just a little loath to get away from this purely scientific viewpoint. But how much greater would his service be, if instead of offering a technical analysis of the problems presented to him, he would give the answer expressed in the language of production, so that it could readily be understood by the engineer.

If we trace the growth of the metallurgical departments, we will find that they have developed in most manufacturing companies from small beginnings into very powerful units.

Not many years ago the metallurgical department was considered something good to talk about and to show to visitors when they came to the factory, but the other departments did not take it very seriously. When business slumped and the management decided to cut expenses, it was the first department to feel the ax. In other words, it was a non-productive department, and therefore an overhead expense that could be eliminated. Having been through two such experiences, I know whereof I speak.

In a manufacturing company, especially one in the automotive field, cooperation among all departments is necessary, and the metallurgical department comes in close contact with them all. Let us take the departments individually and trace the connection.

RELATIONS WITH THE ENGINEERING DEPARTMENT

The metallurgical department should assist the engineering department in both designing and the selection of materials. There are several extremely important metallurgical factors that enter into the design of an automotive part; for instance, sharp corners and improper fillets may cause the failure of high-duty parts and result in serious accidents. A sharp corner, in a part that is subjected to alternating stresses, will lead to fatigue failures due to localizing of the stresses and strains that are set up in the quenching process. When a piece of steel is quenched, the cooling takes place at right angles to the surface. With a sharp corner, this results in stresses being set up at right angles to each other and failure will very likely take place at the corner because the stresses are pulling against each other. With a well-rounded fillet, the stresses are uniformly spread around the corner and the chances of failure are remote. This should be watched very closely in high-duty bolts; a sharp corner in a connecting-rod-cap bolt can easily wreck an entire engine. Flywheel bolts are also important, for failure of one may have serious results.

Unequal sections of metal in a part will cause difficulty in the heat-treating process. An example of this is the mushroom type of gear, shown at the left in Fig. 1, that has been used sometimes in the transmission. It was almost impossible to quench a gear like this without excessive warping and non-uniform hardness. The shape was such that there was no way to get it into the oil without causing distortion. Due to the difference in mass between the web of the gear and the stem, there was a certain amount of annealing action on the gear from the heat retained in the heavy section of the stem. This gave non-uniform hardness and was an important factor in the distortion. This trouble was overcome by the design shown at the right in Fig. 1, the gear and shaft being made separately and assembled. The flat gear did not warp when quenched, and the shaft could be given a longer soak in the furnace to assure uniformity of structure, making a much better assembly than that at the left.

The design of castings requires knowledge of foundry practice to see that chills are put in the proper places and to guard against blow-holes at vital points.

MATERIALS OF CONSTRUCTION

The choice of materials is a very important duty of the metallurgist. A few years ago the choice of steels was limited to the carbon, nickel, and nickel-chromium

[1] M.S.A.E.—Metallurgical engineer, Hupp Motor Car Corporation, Detroit.

[2] See *American Machinist*, April 7, 1927, p. 582.

varieties; all excellent steels but not suitable for every purpose. It is only necessary to look at the list of S.A.E. Standard steels to realize what a large field there now is from which to draw. In addition to the earlier varieties mentioned, we have chromium, chromium-vanadium, manganese, silico-manganese, and the various combinations of molybdenum. Each type of steel has its sponsors and users, and the varieties can be substituted for each other to a certain extent. Do not think that I advocate the use of all the various types of steel in one automotive vehicle; the fewer types used, the better it is for the heat-treating department, the machine-shop and the purchasing department.

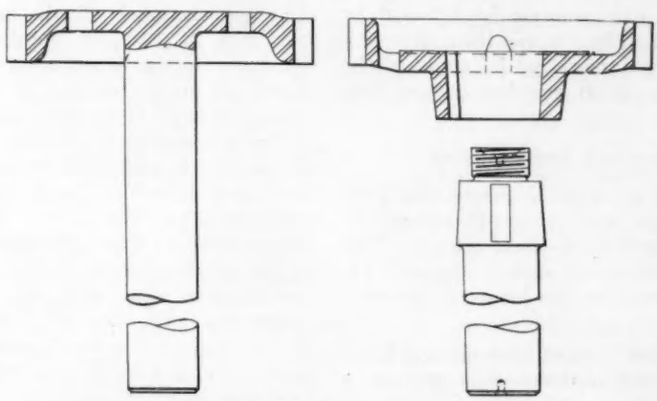


FIG. 1—IMPROVING THE DESIGN OF A GEAR

When Made as in the View at the Left, This Gear Caused Trouble from Warping and Non-Uniform Hardness. When Made with a Separate Shaft as Shown at the Right, These Troubles Were Remedied

Recently, I interviewed an advertising man who asked: "How many different types of S.A.E. steel do you use?" "About ten," was the reply. "Oh, damn, I hoped there were 40 or 50; it would make such an impression on the buying public if we could give a long list."

In addition to the steels already standardized, several special steels are being advertised and pushed. I hold no brief against them, but I firmly believe that the ones which have been tested and proved will fill the need for all automotive parts. The Iron and Steel Division of the S.A.E. Standards Committee has worked long and hard to bring the standardization up to the present level, and this is a plea for your support of its efforts. The Division is now working on a new method of developing physical-property charts which should be of assistance to the designing engineer and give him a more comprehensive idea of the working limits of a given steel than he can get at present.

In experimental designs, the metallurgical department

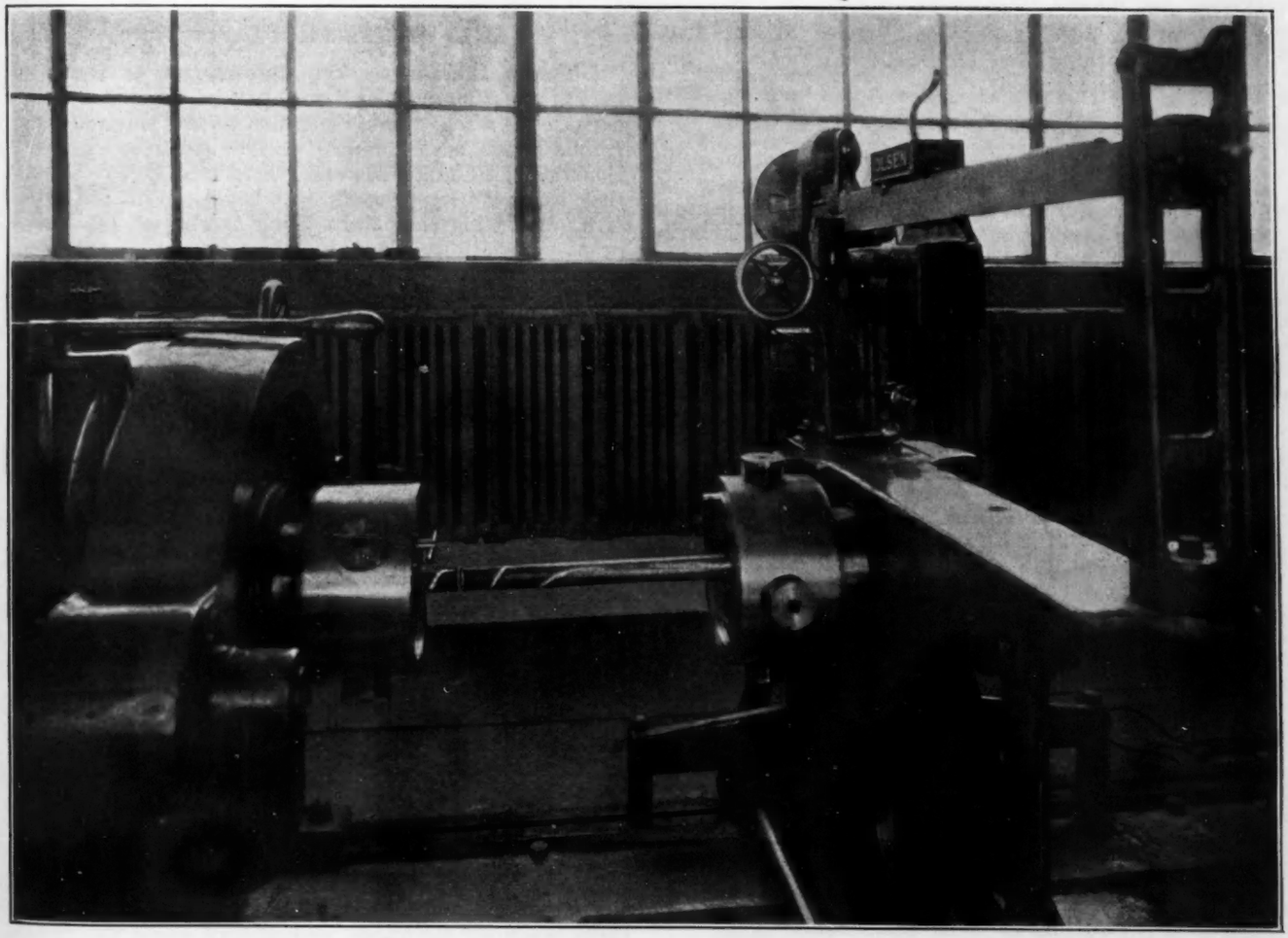


FIG. 2—AXLE-SHAFT IN TORSION-TESTING MACHINE

The Ultimate Strength and the Elastic-Limit of Many Parts Can Be Determined by Actual Full-Size Tests in Torsion, Tension or Compression. This Is Considered Better than Making Tests on Test-Bars

should work closely with the engineering department by testing parts, assemblies and units, to see that they will meet the requirements. Liberal use must be made of the physical-testing machines, to check designs before they go into production.

Assisting the Purchasing Department

The metallurgical department should assist the purchasing department by visiting contemplated sources of supply and making an inspection of their plants. The following points should be observed and a detailed report upon them should be made to the head of the purchasing department:

(1) Type of building; whether of good construction as regards fire hazard and provided with proper fire protection
(2) Condition of the plant whether kept in an orderly and neat condition and one that would give the impression of doing careful work
(3) Heat-treating department; a careful inspection should be made with special attention to the equipment
(4) Methods and thoroughness of inspection
(5) Shipping facilities; whether the plant is located on branch or main lines of railroads and so that the material can be handled promptly and without being transferred at various points

Perhaps the most important result of a visit of this sort is the establishment of a personal contact between the two organizations and giving the supplier the point of view of the purchaser, so the former will be made aware that nothing but high-class workmanship and materials will be accepted.

How the Metallurgist Helps Production

Having worked with the engineering department in solving its experimental problems, it now becomes the duty of the metallurgical department to see that the materials used in production measure up to the standards required by the design.

The physical and chemical inspection of incoming materials and parts should be done very carefully, to see that the analyses are as specified and also that the heat-treatment has been such that the parts will withstand the stresses and shocks to which they will be subjected. It is my opinion that tests should be made on the actual part or assembly rather than on a test-specimen. Connecting-rods, rear-axle shafts, propeller-shafts, and steering-gear connecting-links can be easily subjected to tensile, compression or torsion tests to detect the weak spot in the assembly. Fig. 2 shows a rear-axle shaft after being broken in a torsion machine. All high-duty bolts and studs, such as connecting-rod-cap bolts, cylinder-head studs, piston-pins, and steering-knuckle pivots, can be checked physically to determine the actual elastic-limits and breaking loads. This information should be of great value to the designing engineer. Compression tests on assembled pistons and pins also are of value to the designer, showing him where to strengthen the piston without adding unnecessary weight.

Another duty of the metallurgical department is to keep in contact with the machine-shop to see that the parts machine properly, as to both cutting speed and finish. Proper normalizing and annealing will save much trouble in the machine-shop.

Control of Heat-Treating

The heat-treating department should be under the strictest supervision of the metallurgical department. The metallurgist should study each individual part to see how it can be handled rapidly and economically through the furnaces, always keeping the idea of quality foremost in his mind. With the advent of continuous-conveyor-type furnaces equipped with automatic control of both speed and burners, with recording pyrometers, signal lights and other refinements, there is little excuse for unsatisfactory heat-treating, provided the proper temperatures, times and handling of parts have been designated by the metallurgical department. From a study of the design of the parts to be heat-treated, the metallurgist can work out special fixtures for handling them that will cut the heat-treating costs considerably and still give a product better adapted to its use. This is especially true in carburizing work of which certain portions need to be hard while the success of the part depends on the proper toughness of the remaining portions. In ways like this the metallurgist surely functions on a production basis and can more than repay the costs of his department by the improvements and savings he can effect.

At present there are three recognized methods of checking hardness: Brinell, Rockwell and Shore. They vary in application, and by use of all three every vital part can have careful inspection. It is my opinion that hardness inspection should be made of each individual part having to do with the safety of the occupants of the car. Microscopic and macroscopic examination in addition to this, will give a complete history of the part.

Data for the Sales Department

Dissemination of accurate information to the members of the sales force is a vital part of the metallurgical department's job. Many salesmen at the National automobile shows have given to visitors ridiculous information regarding materials and treatments, simply because they had not been properly instructed. With the extensive advertising campaigns being carried on by various brass associations, alloy-producing companies and steel-producing and steel-consuming companies, the buying public is becoming interested in the materials used in the car, especially in its vital parts. Short snappy talks at dealer's meetings will be valuable to the sales department in passing along information that can be used to good advantage on the sales floor.

Distributers and dealers are continually asking for information regarding the proper kinds of lubricant to use in various parts of the car. I believe it is wrong to restrict the user to a few recommended makes of lubricant, because not all are obtainable universally. Let the selling agent submit samples of the brand he wishes to use and have them properly checked. By doing this, much trouble can be avoided.

Problems from the Service Department

The metallurgical department functions with the service department in several ways. The first is by checking incoming service-stock. The same rigid chemical, physical, and microscopical examination should be made on service stock as on production material. The requirements should be held to narrow limits, and off-analysis material should not only be rejected but should be marked so that it cannot be used.

Another way is by examination of parts returned. Unfortunately, parts of automotive vehicles will sometimes wear out or break, and in such cases the metallurgical department should be of very great value to the company. If the part is broken, the cause of failure

should be found. It may be due to faulty material, poor design, carelessness on the part of the owner, or an accident. If it is due to the material, the supplier surely should be informed of the trouble he has caused; if it is poor design, the most careful analysis of the failure and the causes leading up to it should be made and a detailed report turned over to the engineering department, so that the design can be improved and the prospect of further trouble eliminated.

Guarding Against "Pirate" Parts

Nothing can cause more trouble to a company than the use of substitute parts, commonly called "pirate" parts. It is one of the hardest things to combat in the automotive world. So many fly-by-night stores sell repair parts for cars that the pirate-parts business flourishes in spite of all that car manufacturers can do. I have seen rear-axle shafts made from ordinary cold-rolled steel, piston-pins with the case-hardened surface full of cracks, and bushings of soft brass in place of the phosphor-bronze specified, returned for credit by dealers. Owners try to save money by buying "just as good" parts and when they get into trouble they try to get free replacements from the factory. Such claims should be turned down hard.

In this connection, the metallurgical department should work with the parts maker to arrange for special markings or identification numbers so that pirate parts can easily be recognized. One company has its copyrighted insignia placed on several of the more commonly copied parts as a means of protection.

So we see that the metallurgical department has risen from its former obscure and barely tolerated position to a recognized and secure position as a valuable adjunct to all other departments and a power for the good name of the organization of which it is a part.

Connecticut Motor-Vehicle Law

IN Connecticut a person who desires to secure a motor-vehicle operator's license, for the first time, is obliged to undergo an examination, oral as to the law and practical as to the road test, in a vehicle supplied by the applicant. An eye test is also given. These examinations are given by officers of the State Police force at 36 different places in the State at certain specified times. An operator's license issued by another State is not good for the operation of a Connecticut-registered car.

Any person operating or in charge of a motor-vehicle must give his correct name and address or that of the car owner and produce license and registration certificate, upon demand, at any time, of any police officer in uniform, or upon demand of any person in case the vehicle is involved in an accident.

When any material change is made in the appearance or mechanical equipment of a car so that it no longer corresponds with the data contained in the original registration certificate, the Commissioner of Motor Vehicles must be notified of the changes, within 48 hr. of their being made. An engine should not be changed from one car to another or a new engine installed unless application to make such change has been made and permission granted. When a holder of a license or certificate of registration changes his address, he must notify the Commissioner within 48 hr. of such change, giving both old and new addresses.

"Light weight" is defined as being the weight of an unloaded vehicle as ordinarily equipped and ready for use, but exclusive of the weight of the operator. The sum of the light weight and carrying capacity of a vehicle, or vehicles operated in combination, shall not exceed 26,000 lb., formerly 25,000, except by special permit issued by the Highway Commissioner.

Appropriate fees are provided for registering pneumatic-tired commercial vehicles of more than 4-tons capacity; this to encourage the use of pneumatic instead of solid tires on heavy-duty vehicles, in the interest of highway upkeep.

On and after Jan. 1, 1928, a minor cannot register a motor-vehicle unless he furnishes, as a pre-requisite to registration, proof of financial responsibility.

Equipment

Every motor-vehicle, except a motorcycle and motorcycle and side-car, while in use upon the highways, must be equipped with a windshield cleaner, in good working-order.

Brakes shall be of sufficient power to lock the wheels of the vehicle while it is in motion.

No light, on any automobile, which is visible from the front should be of any other color than white or amber tint, except that in the case of jitneys a small purple distinguishing-light may be used by special permit. The display of red from the front of a vehicle in any kind of light or device is prohibited.

Fire apparatus and police patrols may be equipped with siren horns, but no other vehicle can be so equipped except by special permits, which are issued only in rare instances when police and fire-department officials are agreeable to the use of a siren by someone outside of their jurisdiction.

All cars must be equipped with headlight devices which are on the approved list. Twenty-one candlepower is the maximum for any electric lamp or bulb used in such devices. Driving during hours requiring artificial light with only one head-lamp lighted is a violation of law. The use of accessory lighting-appliances in combination with approved devices is discouraged, because it is believed that there are enough efficient approved devices to meet all needs, if they are properly used. However, accessory devices may be used by motorists upon their own responsibility, provided they do not conflict with the legal requirements in regard to sufficient amount of road light. Connecticut has no approved list of tail and signal-lights but any such light which complies with the Massachusetts requirements will be satisfactory. When tail-lamps are lighted, they shall, in addition to showing red to the rear, also sufficiently illuminate rear number-plates with a white light to make them legible at a distance of 50 ft.

Tractors and electrically operated platform-trucks need not necessarily be equipped with approved headlight devices.

Other Provisions

Proof of financial responsibility to satisfy any claims is, briefly, $5,000 to $10,000 as regards public liability and $1,000 as regards property damage.

Operating a motor-vehicle upon the highway at such speed as to endanger the life of any person, other than an occupant of such vehicle, shall be construed as reckless driving and subject to the same penalty, but if such operation endangers the life of any occupant of such car, and not of any other person, it shall be construed as speeding, and subject to the penalty provided for that offense.

Prima-facie evidence of reckless driving and speeding is based upon the evidence submitted in support of the charge that an alleged violator was operating recklessly under existing highway conditions, or so as to endanger the life or limb of any person, or at a rate of speed greater than was reasonable, as the case may be.

Operation down-grade, upon any highway, of a commercial vehicle with clutch or gears disengaged, is construed as reckless driving.

Any owner of a commercial vehicle who allows it to

carry an overload may suffer revocation of the registration of that vehicle; this in addition to penalty applicable to operator of such a vehicle.

A motor-vehicle must not be parked on a curve, nor at the top of a grade unless the vehicle may be clearly seen for a distance of 150 ft. in either direction; nor within 50 ft. of a vehicle already parked upon the opposite side of a highway; nor on highways in the night season without proper vehicle-lights displayed, unless the vehicle is clearly visible in every direction for a distance of 200 ft. Parking rules are subject to minor changes within the limits of such cities and towns as have passed ordinances. Traffic regulation by officers or signals, in municipalities, is wholly a matter of local ordinance.

A motor-vehicle with the engine running must not stand upon any highway unless there is someone in the car capable of controlling it, or the brakes are set.

A repair-man or automobile mechanic who receives any motor-vehicle for the purpose of repairing it must obtain from the owner or possessor of such vehicle a written authority for any expenditure upon it in excess of $50. If he does not do so and any dispute arises over the repair bill, no civil action can be maintained for any charge exceeding $50.

There is no law specifically prohibiting the riding of three persons on the front seat of a motor-vehicle, but if such a practice results in crowding the driver and preventing him from exercising full control over the vehicle, it is possible he would be open to a charge of reckless driving, in case accident occurred.

Accident Reports

It is necessary to report all motor-vehicle accidents which occur whether on public or private property, in which injury, no matter how slight, has been done to any person or damage has been done to property to an apparent extent in excess of $10. This provision applies to owners and operators of other States or countries. The operator of any vehicle involved in an accident should make the report within 24 hr. after its occurrence, but, if for any reason he cannot and it is a case where the operator is not also the owner, the owner must make the report within the same time limit. If a printed report form is not at hand, a brief statement of the accident should be filed by letter, pending the receipt of a form upon which it is thereafter reported in detail and sworn to. Such reports must be made even when only one vehicle is involved and the injury or property damage affects only the operator or owner of that vehicle.

Connecticut allows to properly accredited out-of-State motorists exactly the same "visitors' privileges" as their States of residence allow to properly accredited Connecticut motorists.—From a manual by Deputy-Commissioner Rudd.

Is War Inevitable ?

WAR can be said to be inevitable only if we assume, first, that the conditions which from time to time have led to war were themselves the result of a process of necessity, and, second, that the conditions under which men have been brought to fight in times past were, in fact, those precise conditions under which they would have fought if given a choice. Neither of these assumptions can possibly be maintained. It is conceivable, to say the least, that, considering the cost, the great masses of human beings involved might have preferred some other method of settling any particular dispute. And we know that the conditions which hitherto have led to war are the result of human volition and deliberate choice; not of the populations involved, but of their governments. Even if we admit, as perhaps we must, that so long as governments possess the power, first, to create conditions which ultimately result in a clash of national interests and, second, by declaring war, to force those issues to a test of armed strength; even if we admit, under these circumstances, that history will merely repeat itself and war more or less inevitably follow, we have no reason to admit that a similar result would follow if the power to declare war were in the hands of the populations. That is precisely what we do not know. The experiment never has been tried. And there are considerations which, apparently, point the other way.

Citizenry Capable of Exercising War Power

The great self-governing peoples have shown themselves competent to manage their domestic affairs. Foreign affairs are merely an extension of domestic affairs. There is nothing mysterious about them. They are not a sort of arcana, wherein the laws of common morality are excluded and in which only cynical gentlemen of bilingual attainments are competent to play a role. They are in the main simply the natural and beneficial outcome of a desire to trade. They become potentially dangerous only when men who temporarily possess power undertake, for a supposed national advantage, to infringe either the liberties or the possessions of a neighboring people. Then they become very dangerous indeed. But, insofar at least as the great self-governing peoples are concerned, does a sound foreign policy now necessitate either? Or is such an effort as likely to grow out of great masses of men and women whose interests lie primarily in peace, as out of small groups of men who think, perhaps, they can better the relations between them and, sometimes as history has shown us, are willing to take a chance? It is conceivable, indeed, that what men call "national destiny" might safely be left to work itself out more slowly and in its own way, and without so much conscious aid and direction.

The power to declare war subordinates all other powers to itself. It represents the highest act of sovereignty. It is the one power which of all others a self-governing people would logically reserve to itself, since it puts in jeopardy their collective lives and property. And yet, strangely enough, it is the one power they do not possess. We create governments primarily to protect our individual lives and property. To that end, we make laws and set up legislative safeguards, and, if these prove unsatisfactory, we change them. It is only when all our lives and all our properties are suddenly involved in a great and supreme decision affecting peace or war that we cease to be self-governing. We accept the decision of others. The fact that self-governing peoples choose their own governments and are, therefore, presumably responsible for the actions and decisions of those governments, does not meet the issue. Those governments are never elected on the precise issue of peace or war. They are elected on domestic grounds and for domestic reasons. And a government elected primarily on an issue such as the tariff, let us say, may not be at all representative when suddenly confronted by the need of a decision involving peace or war.

If the danger of war is to be lessened, a sufficient measure of control, it seems to me, can be obtained only when the self-governing peoples definitely and constitutionally take the decision into their own hands.—Alanson B. Houghton, ambassador to Germany and to England, at Harvard University.

Vol. XXI October, 1927 No. 4

Integrated Production

By E. P. Blanchard[1]

Production Meeting Paper

WE are in a new era of production that has been made possible by the broader vision of the production engineer, who is now an established factor in industry because of the demand for reduced production costs. The two factors over which he has control are labor and machinery. Labor cost is of diminishing significance as machinery takes over an increasing proportion of the responsibility for performance.

To the two production principles of the division of labor and the transfer of skill to machinery is added a third principle deduced from facts observed in modern production practice. This principle is integrated production, the combining of work units, which are the smallest possible divisions into which operations are broken down by the time-study man, so that a number of identical or similar operations are performed simultaneously by multiple tools, with the maximum efficiency and economy for each tool or each work unit.

This calls for increasingly greater refinement, from multiple tooling to provision for performing at one time operations governed by differing conditions. It can be carried to any extent justified by resulting economy. The point at which economy ceases to increase is determined by calculating carrying charges on the equipment against the operating cost of production. On greater quantities, as refinement is carried to greater limits, the savings in each case become less; the economy curve flattens out considerably long before "mass production" is reached.

Integrated production also combines the division of labor, the transfer of intelligence to machines, and the simultaneous performance of work units in a way to comprise a complete process or method performed in the shortest possible time. This results in smaller inventories of raw materials and materials in process, greater flexibility in the manufacturing process, quicker turnover from raw material to finished product, shorter financing periods, less money required and less tied up in forms subject to loss. Such savings, on a National scale and in the volume represented by the automotive industry, must contribute to the present favorable financial situation. Thus the production engineer is an important factor in such an ultimate phenomenon as the National prosperity of the Country.

THE present is a new era of production made possible by the broader vision of the production engineer. That vision was not granted to him in a day. He followed the dictates of common sense and engineering practice step by step from his original job of stock-chasing to an ultimate planned flow of work in process. He has coordinated performance, he has studied the habits of labor and the performance of machinery to obtain greater efficiency. He has time-studied and now he cost-studies every job, every move for economy. He is, himself, a product of integration. His job has been created by the building up of one phase of the work after another to a complete, effective and essential factor in the business of manufacturing.

That he is an established factor is evident, for it has been decreed by those who do the plain and fancy decreeing that greater profit per unit is the present objective. But they have not asked the salesmen to sell at higher prices; instead, they have asked the production engineer to reduce cost; and the career of the production man promises, from past performances, that somehow he will accomplish this objective.

Getting down to cost facts and the principles, there are two factors that are controlled largely within the shop. Material specifications are determined by the engineering department, but the finished form which the materials must take is accomplished by the production man with labor and machinery. Working with these two factors, he must reduce cost.

The labor-cost factor is becoming less and less significant. This diminishing of labor-cost began more than 150 years ago, when it was determined that a short cycle of operations by each workman, performed frequently, resulted in faster and cheaper production than letting one man worry through the complete process to the finished product. Motion studies and time studies have given us our present efficient workman. But, in his evolution, machinery came into the picture and has gradually taken over more and more of the responsibility for performance to the point where the modern manufacturing process is preponderantly a machine process. These two production principles, the division of labor and the transfer of skill, which have been evident in years past and with which all are familiar, are brought to attention because we may now deduce a new principle in production from some of the facts that can be observed in modern production practice.

Work Units Combined for Greatest Efficiency

The time-study man knows that any piece of work can be broken down into the operations of which it is comprised, and that the machine time on each operation can be figured very accurately. He knows that, with each tool cutting efficiently in each operation, a definite length of time will be required to accomplish the job. With all the mechanical factors in the tool itself which determine maximum efficiency, such as form of the cutting tools and the speed and feed, held constant and unimpaired, the total accumulated time per tool for all operations on a given piece of work will be the same whether the work is done with only one tool cutting at a time or with 3, 13 or 30 cutting. The production time for the piece will, of course, be shorter with more tools cutting, if the correct mechanical factors of tool efficiency are maintained in each case. Actual cutting time is shortened by the multiplication of tools in simultaneous operation. Let us coin a word and call this "simultation." It is a mathematical factor and holds true of machine performance in any process of manufacture; whatever the job may be, if it is broken down into the smallest possible work units, the accumulated time of performance for all work units will be the same, though there is a saving in total production-time by the combining of work units and by the "simultation" in performance.

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In building the production process, however, these work units are combined, with careful study and attention to the conditions that will assure greatest efficiency; that is, the mechanical factors in tool performance must remain unimpaired. This process of combining work units for highest efficiency is integration.

A Refinement of Integrated Production

One cutting tool traversing the length of a plain straight bar in turning will require three times as long as three tools for the same purpose working simultaneously; therefore, the "simultation" in this case is three. But if the bar is to have two different diameters and the rate in feet per minute requires a different spindle-speed on each diameter, the bar becomes two separate work units which cannot be combined under the same conditions. They are not subject to "simultation" except by compromise in the factors. The same is true in milling operations. Two different milling-cutters may be mounted on the same arbor but, if the work requires two different diameters of milling cutter which justifies a change in cutter revolution to maintain the proper cutting speed, here again are two separate work units. Work units may be multiplied indefinitely in this way and in all kinds of work, even in the production process itself, for the complete manufacturing method from raw material to finished stock is but a combination of work units, each performed under the conditions and circumstances suiting each unit which best adapts it to highest efficiency. This can be seen in printing presses, knitting machinery, looms, paper making, or whatever. The principle is universal.

In metal cutting, however, the work units or operations of which the finished job is composed must be combined in a way to comply with the nature of the work, and special attention must be paid to the limits of mechanical performance of machinery in any one unit. Further, in combining the units, an exact balance of work allotted to each must be maintained. To do this may require splitting certain of the longer operations or splitting some of the greater units and increasing the "simultation" in the job, so that with every factor of the machine performing to its highest efficiency, or every work unit being performed at the highest possible rate, they will "time" to a least common multiple. The process to the ultimate finished piece will be performed in the shortest possible time. This, in effect, is a refinement of integrated production.

Simultaneous Operations with Differing Conditions

Obviously, the multiplication of simultaneous operation, with provisions for complying with the mechanical requirements of each, calls for increasingly greater refinement. Multiple tooling is a refinement over one-tool operation, and provision for multiple work-units with varied conditions for each requires refinement over multiple units having the same condition in each. This refinement can be carried to whatever extent is justified by the economy resulting therefrom. As an instance, if in cross-facing a surface of large diameter sufficient economy could be obtained, a machine could be designed to give a constantly increasing ratio of spindle speeds as the tool approaches the center rather than the present periodical change which is included in some designs to compensate for the reducing rate in feet per minute. Even economy in the materials of which cutting tools are made is justified in some cases by the nature of the operation and the work required of the particular tools to accomplish their unit of performance in time to balance with the other units in the piece.

But in working toward greater profit per unit, it must be remembered that every stage in quantity production justifies its own limits in refinement of equipment and methods. In every job there is a point at which economy is greatest for the particular quantity required; any point of refinement beyond this peak of economy enters a period of diminishing returns. This is a proportionate figuring of carrying charges on the equipment necessary as against the operating cost for performance. Fortunately, however, it is fairly simple to calculate where the cost of carrying charges too greatly overburdens the operating cost. It is the part of wisdom to equip for a peak of economy somewhat beyond the proposed production quantity, allowing therein for some expansion and for taking advantage of the most that is justified in refinement. On this point it might be shown that the relative refinement demanded by certain quantities varies considerably in the smaller quantities of production, but that as quantities increase, and as refinement is carried to a greater extent, the savings in each case become less and less. The curve of savings flattens out considerably long before we reach quantities represented by that indefinite term, "mass production."

Referring again to the older principles of production, it can be observed how the breaking down of any job into its small work-units is similar to the principle of the division of labor and how skill in the machine is required for each work unit to meet exactly the mechanical requirements of the operation and the conditions of highest efficiency.

Economies Effected Increase Prosperity

Integrated production goes one step further. It combines the division of labor and the transfer of skill and intelligence in each work unit, properly balanced and performed simultaneously to comprise a complete process or method performed in the shortest possible time. Here is a scientific principle which is old and established in practice but, as a principle, is modern and subject to more extensive application to derive that greater economy which is the objective of production engineers.

As to that economy, which may seem to come in dribblets, if one takes the financial point of view of his own accomplishments, he will see the accumulated results of his effort. In the present automotive-manufacturing process, smaller quantities of materials are in inventory and in work in process, less money is tied up, and, in effect, a quicker turnover results than formerly. Aside from the savings in direct and indirect labor, consider for a moment what the more consistent performance of modern machinery has meant and what factor production has saved. There is the reduction in the raw material inventory, a smaller amount of work in process at all times, and a greater flexibility in the process, which avoids overproduction. There is a quicker turnover from raw material to finished goods, with not only a shorter financing period but smaller amounts of money required and less tied up in forms which are subject to possible loss. Such savings, on a National scale and in the volume which the automotive industry represents, cannot fail to contribute millions to the favorable financial situation that now exists.

It may be a new point of view, but it is worthwhile, for the production engineer to look beyond the problems in his own shop and realize how much he has contributed as a factor in manufacturing even to such an ultimate phenomenon as the present National prosperity. Reducing all causes to the original source, he is, more than any other, the source of our present prosperity.

Vol. XXI October, 1927 No. 4

External Cylindrical Honing

By L. A. Becker[1]

Production Meeting Paper *Illustrated with* Photographs

Because of the slowness and inaccuracy of hand polishing-methods, a machine has been developed for honing the bearing surfaces of crankshafts. The author analyzes the reasons that influenced this development and outlines the problems that had to be overcome.

A clear statement is given of the variables to be controlled in crankshaft honing.

Honing is said to produce a bearing surface smoother and more true to form than can be produced by grinding alone or by grinding and polishing.. This is said to make possible smaller bearing-clearances than are now generally needed, to eliminate the usual initial wear, and to reduce the bad effects of oil-dilution.

The application of honing to other bearing-surfaces is foreseen.

As surely as grinding improves turning, honing improves grinding. Grinding produces a more nearly perfect cylinder than is possible by turning alone, and honing after grinding will produce a cylinder near to absolute perfection. The cylindrical grinding-machine is a precision machine when compared with the lathe. However, grinding errors are frequent and troublesome, and the surface of the work left by the grinding-wheel is far from ideal for a bearing.

That a surface which has been ground is unfit as a bearing is well known, for every manufacturer and every user of crankshafts has endeavored to improve the surface by some method. While these methods have varied to some extent, they have been inherently the same, and their results have been similar. Hand polishing the bearings one by one with emery cloth and crocus cloth, as the shaft is revolved rapidly in a lathe, undoubtedly removes some of the sharpness left by the grinding-wheel, but it is slow and unsatisfactory. The human element and the labor cost are high and the results, depending on the time spent and the spirit of the workman, are often disappointing, since the work is disagreeable and likely to be slighted.

The surface left by the grinding-wheel is shown under a high-powered glass to be composed of sharp ridges and valleys. The dark portion of the circle at the left in Fig. 1 shows such a surface. A cross-section presents a decidedly saw-toothed appearance. However, should a carefully ground crankshaft, taken directly from the finish grinding, be assembled in an engine with sufficient bearing clearance and be very carefully run-in, as it surely needs to be, it will in time develop excellent bearing surfaces throughout. The grinding marks will disappear and the surface will become very smooth. But when this condition is reached, the bearing clearance will be excessive, due to wear both on the shaft and in the bearings in which it turns, added to the abnormal clearance required by the original surface. Grinding errors, if any, would further increase this clearance. This is an extreme example, but it serves to illustrate a condition that can be improved only by improving the bearing surface before the engine is assembled. In other words, the better the bearing cylinder is as to surface and form, the closer can be the initial clearance and the more slowly will this clearance increase.

The honed crankshaft presents bearing surfaces equal or superior to those of a hand-polished shaft that has been carefully run-in for 1000 miles or more. Honing has taken the initial wear from the bearings before the shaft is placed in the engine. This removal of the initial wear and correction of the grinding errors is the essential object of honing. Surfaces honed with coarse and fine stones are shown in the center and right portions of the left circle in Fig. 1.

The process of honing evens the ground surface by leveling off the ridges left by the wheel and, if continued long enough, will result in a very smooth, hard and brilliant surface at a level slightly below the bottom of the grinding marks. Lapping, as distinguished from honing, will likewise remove grinding marks, but the final results are not such as are desired.

Honing and Lapping Compared

It is well to compare the two processes of honing and lapping. Lapping is a method of finishing wherein a block, usually of metal softer than the work to be lapped and machined to approximately the contour of the work, is used with an abrasive of fine grain, or flour. This abrasive is usually in paste form and is applied to the lapping block, or lap, with a swab. The lap is held against the work and the latter is revolved and reciprocated. The lap becomes charged with a part of the abrasive, but the remaining particles of abrasive are free to roll between the lap and the work. This causes pit marks, which, although minute, give to the surface a dull and milky appearance. These free particles also form a cushion between the lap and the work and tend to wear down the low areas as well as the high ones, but to a lesser extent. This reduces the correcting tendency of the lap. The work leaves the operation more or less covered with the abrasive paste, and great care must be taken to wash this off thoroughly, lest some remain to play havoc later.

Honing may be termed a modern method of lapping, using bonded abrasive blocks or stones instead of a metal block charged with abrasive. The stones are arranged in holders and are dressed to the required contour with a diamond. The hone, which is an assembly of one or more stones in the holder, is held against the work as the latter revolves and reciprocates. One of the honing heads is shown in Fig. 2. During the operation, the work and the hone are flushed continuously, usually with kerosene. This facilitates the honing by keeping the stones sharp and the work clean, and does much to prevent the stones

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from becoming glazed. Honing is a much faster operation than lapping, as it removes more material in a given time. It also corrects to a greater degree, and the quality of the finish is much superior to that obtained by lapping.

A Little Honing Shows Grinding Errors

If a hone is applied to a bearing surface that has previously been lapped, and the honing operation is stopped before the lapped surface has been entirely removed, the inaccuracies of the grind, if any exist, are still apparent. The central circle in Fig. 1 shows a partly honed surface, and the circle at the right shows a surface on which the honing has not been carried far enough to remove the chatter marks. High spots only have been honed, as shown by their brilliant luster against the surfaces which have not yet been reached by the hone. This demonstrates the greater correcting action of the hone as well as the superiority of finish.

Grinding errors consist principally of taper, out-of-roundness, misalignment, and high or low centers. However, a bearing may be free from these conditions and yet be more or less chatter marked. These marks may not be very noticeable if they are not deep. A crankshaft may have any or all of these ailments, and the old method of polishing with abrasive cloth could not better any of them, unless possibly the chatter marks. The cloth follows the contour, polishing the low spots as well as the high ones.

Because of the slowness of hand-polishing crankshafts and the inferior finish obtained by that method, the company with which I am connected saw the possibility of developing a machine for this operation. Lapping was first considered and extensive trials and experiments were made, but the results were disappointing. Honing was then tried and, though the proper stone was not procurable, the experiments gave encouragement that suitable stones could be developed. The design of a honing machine was then started and all the elements necessary for this method of crankshaft finishing, such as automatic timing-device, adjustable reciprocating platen and kerosene wash, were incorporated.

After the machine shown in Fig. 3 was built, months were spent in developing stones that would do the work. Six weeks is required to make stones with a vitrified bond, and each shipment of stones received merely pointed the way to the next step. Trials proved that, while the grain was important, the grade and bond were far more important. After trials that seemed endless, a stone was produced which did the work. Since then a wide range of stones, to meet varying conditions, has been developed.

Honing Corrects Inaccuracies

The honing machine has proved suitable for more than production finishing, which was the primary object during its development. To a remarkable degree it is also a correcting machine.

The action of the hone is most forcibly shown by placing a crankshaft in a crankshaft honing-machine, as shown in Fig. 4, revolving it for only a few seconds, and then inspecting the bearings. Chatter-marks that were impossible to detect on the ground surfaces became very noticeable. Also misalignment, taper or out-of-roundness, if existing anywhere, is made very apparent, since only the high spots have had contact with the hone. If the operation is continued long enough, these high spots will receive a brilliant finish, and this brilliancy will be seen to taper off toward the low spots until it disappears entirely, if the error is great enough. Close inspection will show clearly the action of the hone. Where the grinding marks have been only partly honed away, the tops of the ridges show a leveling-off and a polish, while the bottoms of the marks have not yet been reached. If the shaft is honed for a few more revolutions and again inspected, the area of the highly finished surfaces will show an increase, and the chatter-marks and the grinding marks will have become less noticeable. Several distinctive surfaces are shown in the various views of Fig. 1.

If the honing operation is continued long enough, the bearings will acquire a brilliant finish over their entire surfaces, unless the error has been too great to correct. This calls attention to an advantage of the honing machine that should not be overlooked. Not only does it correct grinding errors, within the limits of the stock it removes; it reveals errors that are too great for it to correct. Any error that honing will not eliminate is important enough to justify correcting where it develops. One user of the honing machine was shown that certain connecting-rod bearings were constantly out of alignment. The machine could not correct this in the time required to hone the other bearings of the crankshaft, as the hones would not quite "clean up" these two bearings over their entire surfaces. Once apparent, the error was easily corrected in the grinding operation.

Factors in Honing Analyzed

To appreciate the action of the hone and the importance of the correct grain, grade and bond of stone, the difference between the action of a grinding-wheel and a honing stone should be considered. The wheel is revolved to distribute the work among all the cutting points. Any given cutting point on the face of the wheel is in contact only momentarily with the work being ground. It enters the work and leaves it as the work revolves, removing a chip much the same as does the tooth of a milling-cutter. The honing stone, like the grinding-wheel, has a great number of cutting points; but, since only the work revolves, any given cutting point is in more or less constant contact with the work, depending upon the condition and contour of the surface, much as is the case with a turning-tool. As the work is reciprocated while it revolves, the cutting points have a shearing action over the ridges left by grinding.

The action of a grinding-wheel on a given kind of work depends almost entirely upon the grain-depth of cut. The bond must wear away at the same rate as the abrasive grains wear down, to make the wheel work well. Likewise, the bond of the honing stone must wear away at the proper rate, but, since in honing there is no grain-depth of cut in the sense applied to grinding, this condition must be controlled in another way.

The proper grade and grain of stone must be found for a given type of shaft to be honed; the alloy, the heat-treatment, the quality of the finish grinding, as well as the quality of honed surface desired, all influencing the choice. The proper action of the stone can be controlled further by the speed of the work, the pressure of the stone on the work, the length of time the operation is continued, the wash, and, to some extent, by the rate of reciprocation of the work. Correct dressing of the hone added to these makes eight elements that enter into the problem of honing a given type of shaft. In the order of their importance, they are:

(1) *Grade of Stone.*—The bond must be of such kind and hardness that it will allow the cutting grains to break away upon becoming dull

(2) *Grain of Stone.*—In general, the finer the grain the higher the finish of the honed surface. More

stock can be removed with a coarser grain, however, with but little sacrifice of finish

(3) *Pressure.*—The pressure of the stone upon the work must be sufficient to keep the stone cutting until the bottom of the grinding marks is reached. Too little pressure will result in glazing the stones, just as too light a cut will dull a turning-tool. Too great pressure wears the stone away faster than the cutting particles lose their sharpness, and makes the stones appear too soft. Since the shaft reciprocates as it revolves, the stones must be shorter than the bearings on which they are working. If the reciprocation is ⅛ in., as it commonly is, the stones are ⅛ in. shorter than the bearings. Thus the stone length varies with the bearing length, and the pressure applied must vary in proportion to the length of bearing to obtain approximately a constant pressure per unit of area. Provision is made on the machine shown herewith for quick and easy adjustment of this pressure

(4) *Speed of Work.*—In honing, as in grinding, the speed of the work has a decided influence upon the finish of the surface and upon the proper action of the stone. A stone that does not work well on a given shaft at one speed will give excellent results at another speed

(5) *Time.*—Since honing is a finishing operation rather than a stock-removing operation, it need not be carried beyond the point where a proper and satisfactory finish is obtained. With a fine stone it cannot be carried farther, as the stone becomes glazed and ceases to cut. The action of the hone is very fast at first but slows up as the work progresses because as the surface improves, the bottom of the grinding marks is approached and more surface is presented to the stones. Probably 70 per cent of the desired result is accomplished within the first 30 sec. and 90 per cent within the first minute. Naturally, the quality of the finish grinding will affect these figures greatly. The Schraner machine is provided with an automatic knockout that can be set for any desired length of time. This allows one operator to run several machines

(6) *Dressing of Stones.*—This is of importance with new stones particularly, as it shapes them to the contour of the bearing and gives them an initial sharpening. If the grade and grain of the stones are right, the pressure properly adjusted, the speed of the work correct and the timing properly set, there is seldom cause to dress the stones more than once, so far as their action upon the work is concerned. Each shaft that is put into the machine resharpens the stones with its sharp ridges. Thus there is a cycle wherein the irregularity of the ground surface prepares the stone and the stone removes the irregularity, becoming somewhat dull in so doing, only to be resharpened

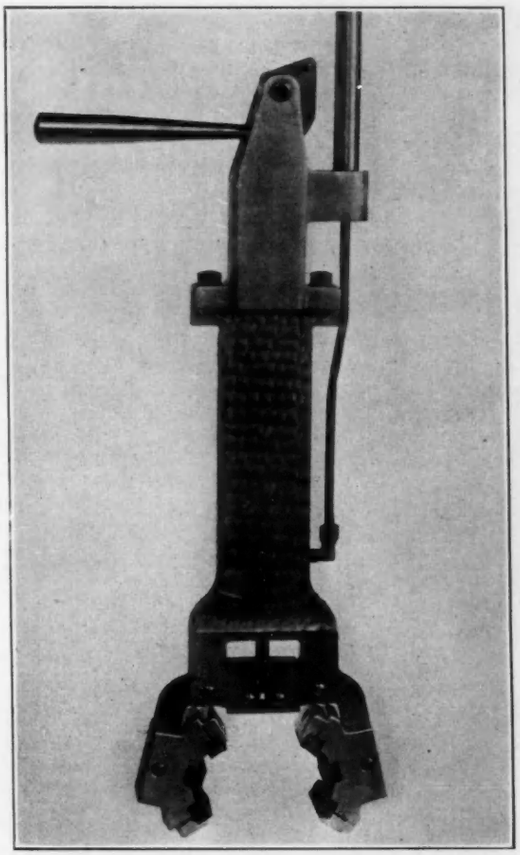

FIG. 2—A HONING HEAD DISMOUNTED

Provision Is Made for Quick and Easy Adjustment of the Pressure of the Stones on the Work. During the Work a Wash Is Fed Continuously through the Lead at the Right. This Is Shut Off Automatically during Loading

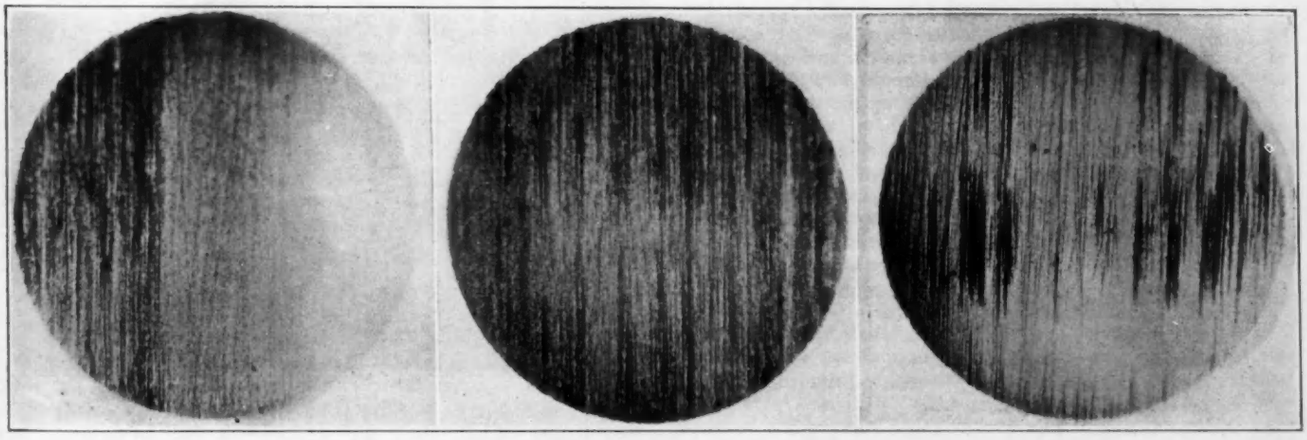

FIG. 1—MICROPHOTOGRAPHS OF GROUND AND HONED SURFACES

The Circle at the Left Shows Three Separate Surfaces. The Dark Surface at the Left Side Is Ground; the Lighter Surface in the Center Is Honed with Coarse Stones; and the Lightest Surface at the Right Is Honed with Fine Stones. The Center Circle Shows a Surface Partly Honed, with Grinding Marks Still Visible. The Circle at the Right Shows a Honed Surface with Chatter Marks Still Visible. In the Engraving All Three Views Are Magnified to 7½ Times the Actual Size of the Surfaces

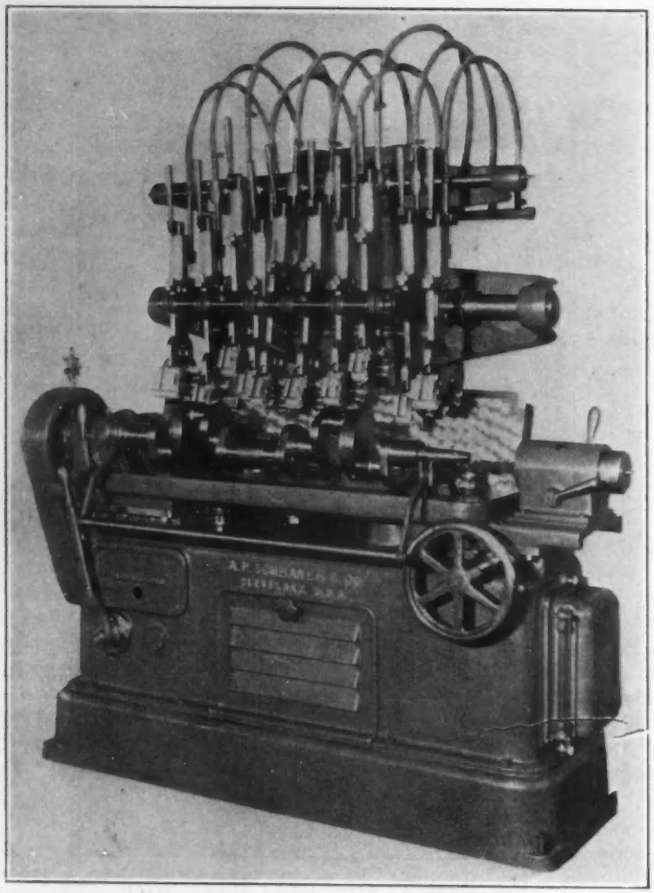

FIG. 3—CRANKSHAFT HONING-MACHINE
This Has an Automatic Timing-Device and an Adjustable Reciprocating Platen, and the Crankshaft Rotates in the Hones. The Honing Heads Are Shown Opened

by the next shaft to be honed. However, if a certain grinding error occurs consistently, it will gradually affect the stones working thereon and their correcting action will be reduced. For this reason it is well to re-dress the stones at least once per day. This trues them and directs attention to any grinding error that may have developed, as inspection of the first shaft ground by the re-dressed stones will immediately reveal it. A machine is provided for dressing the stones with a diamond. Extra stone-holders make it possible to keep one set of hones always dressed and in readiness so that little or no time is lost by the operator

(7) *Flushing of Work.*—The work must be flushed continuously during the operation. This aids in keeping the stones sharp and in preventing their glazing. Kerosene is an excellent wash, and a mixture of kerosene and lard-oil in the correct proportion is even better. The wash is directed to each bearing of the work, as shown in Fig. 3, and is shut off automatically during loading and unloading. Due to this wash, the shaft is very clean as it leaves the machine. A sump is provided in the machine for the wash, which is thoroughly strained and cascaded

(8) *Reciprocation.*—The work should reciprocate as it revolves, to increase the shearing action of the stones and to prevent the formation of grooves in the stones or annular lines on the surface of the work. This reciprocation is readily adjusted so that the stones make contact with the cheeks of the bearings at each end of the stroke

As stated before, the purpose of honing is to remove the initial wear left in an ordinary bearing-surface and to give the bearing a perfect form. By properly controlling the eight elements listed, this can be accomplished with the utmost uniformity and, since all main and connecting-rod bearings are honed at once, the operation is done at a great saving of time over the old method. Thus we have the old story of a machine doing work better and faster than it can be done by hand.

An interesting side-light is the experience that one large manufacturer of motor-cars, who uses the splash system of lubrication, has had with honing. For years, all his crankshaft bearings were polished with large polishing wheels which gave a high finish to the surface but did not entirely remove the grinding marks. This method not only failed to correct any errors, but undoubtedly increased them and caused the development of others. After polishing, the shaft was "burned in" with the engine bearings on assembly in special machines after all the bearing caps were brought up very tight. Babbitt was frequently "pulled" in doing this, whereupon the shaft was rejected, to be re-polished if possible.

HONING MACHINE USED FOR POLISHING

With the trial of a honing machine, an immediate reduction in the number of rejected shafts was noted. Correcting of errors accounted for this, to a large extent.

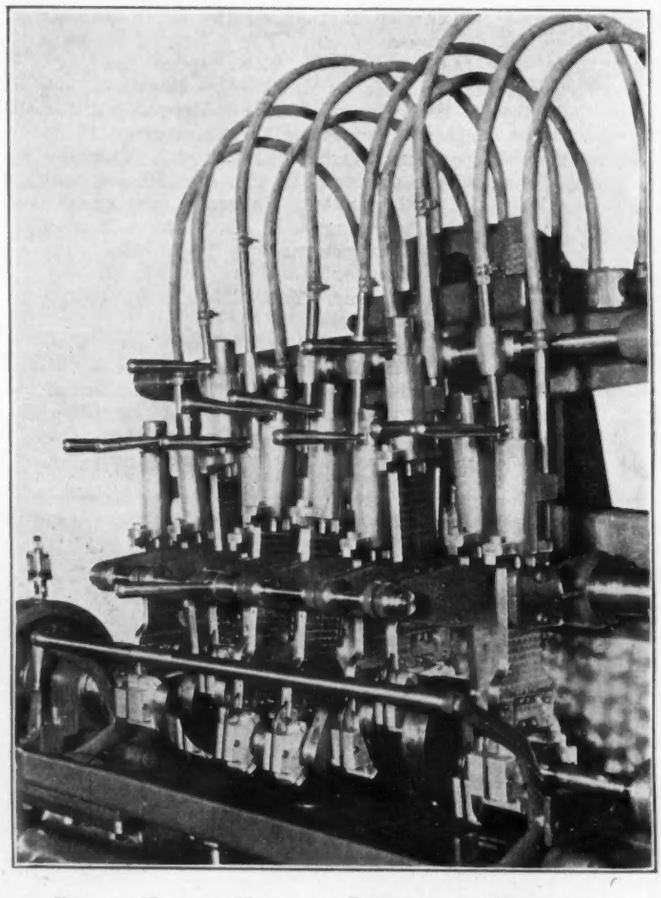

FIG. 4—HONING HEADS IN POSITION ON CRANKSHAFT
The Cams Shown near the Top of the Heads Release the Hones from the Bearing Surfaces. The Honing Stones Are about ⅛-in. Shorter than the Bearings, and the Reciprocation of the Crankshaft Causes Them to Cover the Whole Surface. Honing Heads for the Line Bearings Remain Stationary, While Those for the Connecting-Rod Bearings Are Guided and Allowed To Oscillate Like Connecting-Rods

Further improvement was made by determining the best stone for the conditions and for the finish desired. Experiments were made to determine how fine a surface could be secured with the machine. Finally, ground cork, impregnated with Tripoli, was tried. This was pressed into sticks the size of the honing stones and applied to the shaft after the honing operation. An exceedingly brilliant surface was obtained, which eliminated the "pulling" of babbitt. This development has resulted in replacement by the manufacturer of his polishing machines with honing machines, half of them equipped with stones and half with the impregnated cork. The latter machines run much faster than those equipped with hones, and they have no wash for the work. Otherwise all the machines are identical. The net results to this company have been the correction of errors, the procuring of an exceedingly high finish, and the elimination of babbitt "pulling" with the loss of time incident thereto. All this has been done with a saving of floor space and in the time required for finishing the shaft.

I have said that, with excellent bearing surfaces on a crankshaft, the bearing clearances at assembly can be less than with inferior surfaces, and that the day when the bearings will need to be taken up is postponed. With an unhoned shaft, it is often necessary to take up the bearings of a new engine after only a few thousand miles of use. Cars usually change hands at the end of 2 years of service and are then thoroughly overhauled. If the necessity for taking up bearings can be postponed until that time, the original owner has reason to feel satisfied with his car in that respect.

There is, and rightly should be, much agitation at present concerning the wear caused by oil dilution. This dilution can be overcome partly by frequent oil changes or the use of oil rectifiers or purifiers, and by the judicial use of the choke; but at best there will be some dilution. Surely a bearing that presents a very smooth surface will withstand the effects of diluted oil better than will one with an inferior finish.

Honing of crankshafts has been dwelt upon almost exclusively herein. Surely no part of the engine is of greater importance or requires better bearing conditions than the crankshaft. However, who will say that what has been done on the crankshaft cannot be done on all external bearing-surfaces? Possibly we have just started. If the progress in honing made during the next few years is comparable with that made in the recent past, it is entirely possible that we shall be able to assemble an engine with the initial wear eliminated from every moving part; and to do this more readily and at less than the present cost of manufacture. Experiments that have been and are being made lead to this conclusion.

Foreign Trade and Investment Policy

TODAY we can look back upon one of the greatest periods of prosperity which this Country has ever known. Our wages are still above the 210-per cent level and yet profits, while varying widely in the several industries, have measured up fairly well with the best of the peace-time periods of the last quarter of a century. While our export trade, measured in physical units, after allowing for normal growth, is not above the pre-war relative position, and perhaps not up to it, we have succeeded in gaining a larger percentage of existing export trade than we possessed in the pre-war period. In devoting ourselves during the last five years to reduction in costs and to improvement in product, we have placed ourselves upon a stronger competitive basis in foreign trade.

The two aspects which have caused most apprehension are the increased competitive power of Europe and the movement abroad toward national and international combinations with a view to a larger participation in existing world trade. Notwithstanding the notable increase in the standard of living of the masses of our people, in the aggregate they have been saving at a rate which has left large surpluses in excess of capital need in this Country. Some time ago it became clear that if our capital savings were to be put to the most productive use a considerable amount must be invested in foreign countries.

Four Billions Lent Abroad

Our greatest contribution during the last 5 years to the recovery of Europe and to the foundations for future world trade has been the extension of credit and the lending of capital to foreign countries. During the last 5 years we have lent abroad in the form of new securities placed in our market, excluding refunding, an aggregate amount of more than $4,000,000,000. Part of this has been offset by increased foreign balances in our banks, by paying off of maturing indebtedness, by repurchases by European countries of their dollar securities in our markets, and by their purchase of our domestic securities, but there still remains a large amount in our favor on account of foreign issues placed in our market. To this net amount lent abroad on account of securities publicly issued, there must be added a large direct investment by Americans in foreign industries and in privately arranged participations in foreign financial and industrial corporations. Altogether, our net investment abroad during the last 5 years aggregates a very large sum, and the indication is that the surplus of funds in this Country available annually for investment abroad is on the increase.

In much of our most important trade it is impossible to distinguish between customers and competitors. Our two greatest competitors in foreign markets for many years, Great Britain and Germany, have been our best two European customers. Europe as a whole has taken in the past from 50 to 60 per cent of our exports, and yet Europe has been our great competitor in many markets. It is impossible to lend money for the purpose of rehabilitating our customers without at the same time strengthening the same countries as competitors. Had we refused to assist our competitors in Europe during these last 5 years, we should have gone a long way toward preventing them from increasing their purchases of our goods. If, for example, we were to refuse to extend credit to a great German manufacturing corporation because it manufactured goods competing with those of an American manufacturer, the money which we lend in London or Amsterdam or Zurich or in some other money center, or that which it displaces, would eventually reach the German company.

Cannot Prevent Foreign Competition

Unless we are to put an absolute embargo upon all foreign lending, we cannot prevent our foreign loans from benefiting foreign competitors. Moreover, if we were to follow to its logical conclusion the theory that we should not help a foreign competitor, we should have to place an embargo upon our merchandise exports, for many of them are utilized to help others to compete with us. For example, our exports of machine-tools assist some of our customers in making more efficient machinery or machine products, which in turn compete with similar products of our manufacturers in foreign markets. The transportation equipment and the

agricultural machinery which we sell abroad directly or indirectly help other countries to develop their agricultural resources and to bring their products into competition with our agricultural products in the European markets.

I appreciate that because of the possible attitude of some foreign governments in the future or of the practices of some foreign business and financial institutions it may be necessary to hold in reserve our potential control of foreign investments as a means of protecting our position against foreign combinations. I believe, however, that because of our very important position in the international capital market and increased industrial strength at home we have less to fear from these combinations than perhaps has been frequently believed. It would be unfortunate for the various capital-lending countries to enter upon a series of artificial regulations with respect to the control of export trade by restricting foreign credits. Until, therefore, it becomes clear that we are not to gain through the maintenance of a fairly free capital-market, I believe that our policy should be in this direction.

With the exception of the initial limitations arising from the request of the State Department concerning information with respect to contemplated foreign loans, we have been enjoying a free capital-market. The existence of this market has been of tremendous assistance to reviving Europe and has contributed in no small measure to the development of our foreign trade.

Combinations abroad to divert trade from us, while possibly affecting particular classes of commodities, are not likely to affect materially the total of our export trade. If combinations against our export trade or domestic trade, or with respect to sources of necessary raw materials, should accomplish restrictions seriously affecting any branch of our industry, we would, of course, have to meet them. In the event of such developments it should be demonstrated before imposing restrictions upon export of capital that such limitations would accomplish the desired end, and that the cost of the effect of the limitations would not exceed the benefit derived.

I am sure that in their larger aspects the interests of our investors and of both our domestic and foreign trade will best be served by keeping our capital market as nearly free as is practicable.—J. S. Alexander, chairman of board, National Bank of Commerce in New York.

Advertising Fortifies Prosperity

NEVER before in business history has the force of advertising been so great a factor in maintaining prosperous economic conditions in the United States.

The reason for this lies in the fact that our productive capacity as a nation is so great and is increasing at such a rapid rate that our consuming capacity plus our exports cannot readily absorb all the goods and services that we are able to produce. It therefore becomes necessary to stimulate improvement in our standards of living, by introducing improvements in the products and services that we produce and by inventing new products and services which satisfy newly awakened needs and desires.

Recent years have witnessed notable refinements in many lines of products, such as automobiles, radios, building-construction materials, and food products. New luxuries and conveniences for the homes of the land have been launched in profusion. This development of consuming capacity is achieved largely by the force of advertising, which economically tells millions of consumers about all these better things of life that are now available. It is not now a question of buying power on the part of consumers in the United States, with wages at a high level, with employment conditions, as a whole, satisfactory, and with $26,000,000,000 in savings deposits, but it is a question of how to guide the great mass of people into higher and better standards of living.

Our great economic problem of 1927 is that of keeping our factories and mills busy turning out an adequate supply of necessities *plus* as many improved products and luxuries as are necessary to maintain a volume of production sufficient to keep employment as well as wages up to the levels of recent years. And the solution of this problem embraces more and better advertising, which breaks and cultivates the ground for new crops of needs, desires and ambitions.

In past years, advertising has unquestionably helped greatly in raising standards of living. This year and in years to come, this function of advertising takes on added importance. —*Printers' Ink.*

The Railroad Man

THE function of transportation is the completing of production. Production is the creating of economic value, the making of wealth available for human wants. Transportation, therefore, is not a goal but a means to the goal.

The American railroad-man has been the pioneer statesman of industry. He has been largely responsible for the substantial growth and remarkable expansion of the American industrial system. He has made mistakes, but he has corrected them. He has faced storms of public criticism amounting at times to abuse. He has been a man of vision and optimism. He has accepted the decree of regulation. He has joined whole-heartedly in the operation of his properties by the Government. He has faced problems of reconstruction following the war and has demonstrated the greatest constructive ability of all time in the recovery of transportation from the financial depression which followed Federal control. With such a record of achievement, he will not fail to meet and solve the problems presented in the latest form of competition, motor-vehicles.—R. N. Van Doren, before Railroad Motor-Transport Conference.

Vol. XXI October, 1927 No. 4

Application of Electric Motors to Machine-Tools

By R. C. Deale[1]

Production Meeting Paper

Lack of uniformity in the mounting dimensions of the electric motors built by the various manufacturers leads the author to plead for standardization, with the object of lessening the trouble and expense that non-uniformity causes the manufacturers and users of machine-tools.

After outlining the way in which non-uniformity of mounting dimensions creates difficulties in installation and maintenance, and presenting standard dimensions, attention is called to the facts that a series of standard dimensions already has been worked out to apply to the special motors generally used in steel mills for operating various auxiliaries, and that the dimensions have been accepted by the manufacturers of these motors. In the opinion of the author, it is no more difficult to work to standard dimensions for machine-tool electric-motors than it is in the case of electric motors for steel-mill auxiliaries.

MANUFACTURERS and users of machine-tools and other motor-driven machinery in the United States have been put to great trouble and expense because of the lack of uniformity in the mounting dimensions of the electric motors built by the different manufacturers. Not only does no uniformity in these dimensions exist, but there is very little attempt at uniformity. The old Electric Power Club, now merged into the National Electric Manufacturers Association, drew up a set of standards of shaft extensions which were adopted as recommended practice. These are the only dimensional standards the motor-manufacturing industry has in this Country, and but few companies are following them. This is very much in contrast with the situation in Germany, where the motors built by all manufacturers have the same mounting dimensions.

Table 1 shows the comparative dimensions of the 5-hp. squirrel-cage induction-motors of 40 deg. cent. (104 deg. fahr.) continuous rating at 1200 r.p.m. as built by 13 representative American manufacturers, and Table 2 gives the same information for direct-current motors. As can be seen, only three manufacturers of direct-current motors and three manufacturers of alternating-current motors follow the recommended standard, which has been in effect 8 years. I believe that this shows what progress toward standardization the motor manufacturers are likely to make of their own volition. A strong customer-demand is needed to hasten a complete standardization of mounting dimensions.

Classes of Motor Mountings

Two large classes of motor mountings exist, and these require two degrees of standardization. The first, and oldest class, is still much the larger. This comprises those machines in which some flexible type of drive, such as chain, belt or texrope, is used between the motor and the machine. In this class of drive, the dimensions of the motor-shaft extension, u, n, t, and s in Tables 1 and 2, are of most importance, although dimensions h, a, b, e, and f are also important. Where shaft extensions are not the same, each motor drive must be sent through the shop separately, so that the pulley or sprocket can be machined to fit the motor being used. This naturally delays shipment, as it prevents the use of a standard piece of equipment. It also increases the cost of the machine because the machining of the piece in question requires a special shop-order, usually requires special attention, and always requires an individual machine set-up when the bore is being machined.

Holding-down bolts must also be treated separately, as no one size will do for all motors of the same rating. In the case of the motors shown in Tables 1 and 2, four different sizes of clearance bolt, or seven sizes of body-fit bolt, are needed, depending on which construction it is desired to use. This seems to be entirely unnecessary, especially as most holding-down bolts seem to be considerably larger than is necessary to resist the torque of the motor, or even the combined weight and torque when the motor is inverted. It seems very easy to come to some agreement on this point. The great spread in the mounting dimensions, a, b, e, and f makes it impossible to design a mounting platform which will suit all motors and yet look well. The variance of the dimensions e and f make it necessary to locate the holes for the holding-down bolts from the motor and then either to remove the motor platform from the machine for drilling these holes or to drill them in place by some form of portable drill. Either operation is slow and expensive as compared with drilling from a jig, which could be done if the location of these holes were standardized.

The foregoing operations easily can add a week to the delivery of a machine, and $25 to $50 to its total cost, although much of this cost may not show directly because of being buried in the overhead.

Gear Drives for Electric Motors

In the case of gear drives, the situation is much more serious. This type of drive is being used much more frequently at present than formerly, and is consequently becoming the most important of the various forms of motor drive. Here the shaft extension and holding-down dimensions are just as important as in the previous case. In addition, the dimensions d and x must be considered to assure that the axis of the motor bears the proper relation to the axis of the motor pinion or driven gear. In a drive of this type, it is necessary to make an attachment drawing every time a different motor is used. The

[1] Electrical engineer, Niles-Bement-Pond Co., New York City.

pattern for the base plate usually must be altered or made special, and this base plate always must be put through the foundry and machine-shop separately for each machine.

Because of the lack of uniformity in the dimension *d*, even from that adopted by the motor manufacturer himself, it is necessary to measure this height on the individual motor to be mounted and to machine the base plate to suit that motor. Variations of 1/32 in. or more in the height are not uncommon. Frequently it is found that the plane of the base is not parallel with the axis of the armature, sometimes to so great an extent that it is necessary to take a cut off of the bottom of the motor feet to true them up. All this naturally takes time and adds to the cost; consequently, the delivery time is extended and the cost to the purchaser, which naturally must cover the manufacturer's costs if he expects to remain in business, is higher than it otherwise would be. The variation in the dimension *x*, which some people do not seem to consider seriously, is sometimes enough to require a new base-plate pattern, when the center height is so close to an older pattern that, otherwise, it could be modified slightly.

Motor manufacturers claim that standardization of dimensions would interfere with their freedom of design, but it is difficult to see any great advantage in slight alterations of shaft diameters or of holding-down bolts. Motor designers seem to have differed as widely on these points as on others that are of more importance from the viewpoint of motor design. According to the present status of motor design, it is necessary to use just about the same amount of iron and copper to build different motors of a given rating, regardless of the designer. This is well shown in Table 2, in which the spread from minimum to maximum weight is 20 per cent, while the mean variation from the average weight is only 4 per cent. It is believed that the variations at any particular stage in the art can be taken care of by variations in the lengths *c* and *l*, which are not so important from the viewpoint of mounting.

Dimensional Variations and Standardization

Variations in dimensions between alternating-current and direct-current motors of equivalent rating are not so serious as those in the dimensions of one type of motor as made by different manufacturers, but it would be very desirable if all motors of a given rating, both alternating-current and direct-current motors, were interchangeable as to mounting dimensions. At least one company in the United States and one in England have developed lines of motors in which the alternating-current and the direct-current motor mounting-dimensions are the same; so this is not at all impossible. My understanding is that this interchangeability has been secured in such a way that it has been unnecessary to increase the selling price of the alternating-current motors over the prices of similar motors as sold by competitors.

The difficulties encountered by the machine manufacturer due to lack of interchangeability of motors, as already stated, are passed on to the customer in the form of lengthened shipping dates and increased costs, the causes of neither of which he appreciates. But the most serious trouble occurs after a machine has been placed in the production line. All machinery gives trouble at times and requires attention and repair, and the electric motor is no exception.

In any plant where there is a constant flow of production, it is not possible to allow a machine to stand idle while repairs are being made to the driving motor. Consequently, it is the practice to remove the motor which has given trouble and to replace it by a spare, so that repairs can be made at leisure. When troubles are handled in this way, there is the minimum of interference with production, while, at the same time, electrical re-

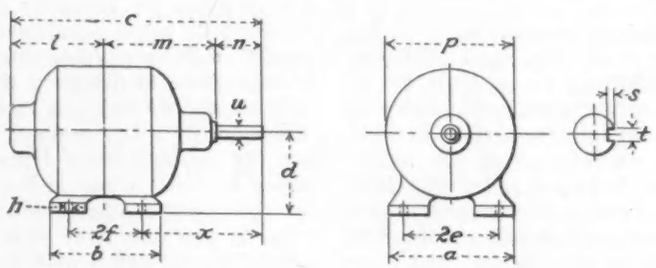

TABLE 1—COMPARISON OF ALTERNATING-CURRENT MOTOR DIMENSIONS[2]

Make	Type	Frame	Shaft Extension, In.				h	d	b	2f	a	2e	x	l	m	c	p
			u	n	t	s											
Allis-Chalmers[3]	AR	110-D	1 3/8	5	3/8	3/16	4 1/64	6 1/2	11 1/8	8 1/2	12 1/4	10	.....	.....	.....	.....	12 3/8
Louis Allis	HD	L 61S	1 1/4	3 3/4	1/4	1/8	2 1/32	7 3/4	9 1/8	8 1/4	14 3/4	11 3/4	8 7/16	9 5/16	9 9/16	22 5/8	14 1/2
Century	S C	8 B	1 1/2	4 1/2	3/8	3/16	1 7/32	7	12 7/8	10 1/2	13	10 3/4	8 13/16	9 21/32	9 7/8	24 1/32	13 5/8
Crocker-Wheeler	Q	13	1 1/2	3 3/4	3/8	1/8	2 5/32	7 5/8	11 1/2	9 1/4	14 1/2	12	8 3/4	9 5/8	9 5/8	23	14 3/4
Electro-Dynamic[4]	AK	131	1 3/8	3 1/2	3/8	1/8	1 31/32	8 3/8	8	6 1/4	16	13 1/2	.....	.....	.....	.....	16
Fairbanks-Morse	B	8 C	1 7/16	4 1/2	3/8	3/16	1 7/32	7 7/16	9 3/8	7 1/2	15 3/4	12 1/2	10 5/16	9 7/16	9 11/16	23 5/8	14 7/8
General Electric	KT	946	1 1/4	4	1/4	1/8	2 1/32	7	11 1/4	9 1/4	14	11 1/4	8 1/2	9 7/16	9 1/8	22 7/16	14
Lincoln	D	212	1 5/8	4 5/8	3/8	3/16	2 9/16	6 3/4	12 3/8	10 3/8	12 5/8	10 1/4	9	9 1/4	9 9/16	23 7/16	13
Reliance	AA	22	1 1/4	3 3/4	1/4	1/8	1 19/32	6 3/4	10	8	13	10 1/2	8 7/16	8 5/8	8 11/16	20 11/16	13 1/4
Robbins & Myers	L	630	1 1/4	3 3/4	1/4	1/8	2 9/16	7	7 1/2	6	12 1/2	10	10 3/8	9 7/16	9 5/8	22 15/16	13 1/4
Star[4]	A	45	1 7/16	5	5/16	5/32	1 17/32	7 1/4	9 7/8	7 1/2	14 5/8	12 1/2	.....	.....	.....	.....	13 7/8
Wagner	RP	11T	1 5/8	4 11/32	3/8	3/16	2 1/32	7 3/8	12	9 1/4	15 1/2	15	8 15/32	8 3/4	8 3/4	21 27/32	13 7/8
Westinghouse	CS	254-C	1 1/4	3 7/16	5/16	1/8	2 1/32	6 1/4	14 3/4	12 3/4	13 1/2	10 1/2	6 1/16	9 5/8	9 5/8	22 1/16	11 9/16
N.E M.A. Standard	.....	.....	1 1/4	3 3/4	1/4	1/8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

[2]These are 5-hp. squirrel-cage induction-motors of 40 deg. cent. (104 deg. fahr.) continuous rating at 1200 r.p.m., two or three-phase, with sleeve-bearings.
[3]Roller bearing.
[4]Ball bearing.

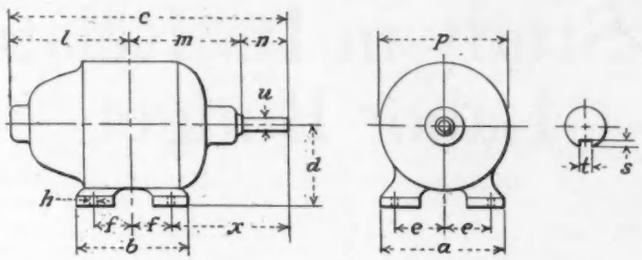

TABLE 2—COMPARISON OF DIRECT-CURRENT MOTOR DIMENSIONS[5]

Make	Type	Frame	Shaft Extension, In.				h	d	b	a	f	e	x	l	m	c	p	Net Weight, Lb.
			u	s	t	n												
Allis-Chalmers	E	70	1 3/8	3/16	3/8	5	4 1/64	8 1/4	13 3/4	15	5 1/2	6 1/8	10 3/8	15 1/2	10 7/8	31 3/8	15	375
Louis Allis	NA	L630	1 1/4	1/8	1/4	3 3/4	2 1/32	7 3/4	11	14	4 5/8	5 7/8	9 7/16	12 13/16	10 5/16	26 7/8	14 3/4	330
Century					No Direct-Current Motor													
Crocker-Wheeler	F	I	1 1/4	1/8	1/4	3 7/8	2 5/32	8 1/4	13 1/2	13 1/4	5 5/8	6 9/16	8 11/16	11 13/16	10 7/16	26 1/8	15 1/4	330
Electro-Dynamic[6]	SC	1	1 3/8	3/16	3/8	4 11/16	1 1/16	8 7/16	11 3/8	13 1/2	4 15/16	5 5/8	8 9/16	11 1/8	13 3/8	24 1/2	16 1/4	365
Fairbanks-Morse[6]	DH	70	1 1/4	1/8	1/4	3 3/4	2 1/32	9 1/8	11 1/2	18	4 1/2	7 1/2	8 1/4	12 1/16	9	26 9/16	17 3/4	355
General Electric	CD	65	1 1/4	1/8	1/4	3 3/4	2 1/32	8	11 3/4	15 1/8	4 5/8	6 5/16	8	15 3/8	8 7/8	26	15 7/8	350
Lincoln					No Direct-Current Motor													
Reliance	T	23	1 1/2	1/8	3/8	4 15/16	2 5/32	8 1/4	14	15	5 5/8	6 9/16	9 5/8	14 1/8	10 5/16	29 3/8	15 3/4	350
Robbins & Myers																		
Star[6]	SB	5	1 7/16	5/32	5/16	5	2 1/32	7 13/16	10 7/8	15 3/4	4 7/16	6 7/8	9 1/8	11 1/8	8 1/2	24 5/8	15 1/4	396
Wagner					No Direct-Current Motor													
Westinghouse	SK	33	1 1/2	1/8	3/8	4 1/2	2 5/32	8 1/4	13 1/2	16 1/2	5 5/8	6 9/16	9 5/8	14 15/16	10 3/4	30 3/16	15 7/8	346
N.E.M.A. Standard	.....	.....	1 1/4	1/8	1/4	3 3/4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

[5]These are 5-hp. constant-speed sleeve-bearing direct-current motors of 40 deg. cent. (104 deg. fahr.) continuous rating at 1150 r.p.m.
[6]Ball bearing.

pairs can be handled in a much more thorough and systematic way. The cost of repairs usually is less in this way, and the repair department can run much more evenly when it is not necessary to hurry jobs through to prevent machines from standing idle. With the great variations in mounting dimensions, it is difficult to do this. It is impossible to replace a motor of one make by one made by a different manufacturer without considerable contriving. In addition, the frequent changes in dimensions by individual manufacturers make it difficult to replace a motor by one built only a short time later. Changes have been made by some manufacturers on the average of every 2 or 3 years for the last 10 years, and there seems to be no good reason for this.

The electrical engineers of the iron and steel industries have worked out a series of dimensions for the special motors generally used in steel mills for operating the various auxiliaries. These dimensions, which are the same for both alternating-current and direct-current motors, have been accepted by the motor manufacturers and are now being followed by one of the largest companies. It seems to be no more difficult to work to standard dimensions in the case of standard motors than in the case of these steel-mill motors. The only difference is the larger number of manufacturers who produce standard motors.

Standardization of the steel-mill motors was secured by concerted demand of the steel-mill engineers. A similar concerted demand by the manufacturers and users of machinery of all sorts, of which machine-tools are only a part, should go far toward securing a similar standardization of standard motors. The Germans, who always have been good engineers, have shown that such standardization is entirely practicable.

Petroleum Production in 1925

THE world's production of crude petroleum in 1925 amounted to 1,067,761,000 bbl., of which the United States produced 71.5 per cent. This is a record figure, chiefly by reason of the 50,000,000-bbl. increase in the United States. The output of the second largest producing nation, Mexico, fell off approximately 25,000,000 bbl., but most of the other large producing countries registered gains. Venezuela, for the second successive year, more than doubled its output.

All the major producing areas of the United States, with the exception of the Rocky Mountain district and the Central States, registered gains over 1924. Production in the Mid-Continent field, which comprises more than half of the total for the Country, increased 13 per cent and was mainly responsible for the increase in National output. A slight increase in production was recorded in California as contrasted with the decline in 1924. The Appalachian field also registered a slight increase in production, this being the first year since 1919 that the output of this field has not declined.

Imports of crude petroleum during 1925 amounted to approximately 61,824,000 bbl., a decrease from 1924 of 20.5 per cent. Mexico, from which the United States imported 55,049,000 bbl., continued to rank as the most important foreign source of supply. Imports from Venezuela, including imports recorded by the Bureau of Foreign and Domestic Commerce as from the Dutch West Indies, amounted to nearly 5,000,000 bbl., as compared with a little more than 1,000,000 bbl. in 1924. Exports of crude petroleum in 1925 amounted to approximately 13,335,000 bbl., a decrease from 1924. Most of this oil was shipped to Canada.—Bureau of Mines.

Time-Study in Its Relation to Labor Budget

By E. J. Frounfelker[1]

Production Meeting Paper

IN the early days of time-study work, the labor cost was obtained after production had started and after the tools and machinery had been made; but use of the control budget, by which all controllable expenses such as non-productive supplies, non-productive labor and other miscellaneous expenses for a given production were predetermined constituted a progressive step which led to the establishment of time-study departments. The control budget of the past did not include productive-labor costs.

The method used by the company represented by the author for the predetermination of labor costs is outlined. After the working drawings are approved, a committee of the manufacturing department, on which is a representative of the time-study department, discusses tools, equipment, methods and labor costs, and makes comparisons with other models. The labor cost is budgeted after careful analysis in which tools, equipment, comparison with other models, and itemized time-elements are considered in the sequence in which they are to be performed. Analysis of the different time-elements is presented by the author, and a summary is made of the advantages of the method described and the results obtained.

COMPETITION in the manufacturing industries brought about piecework production and this developed the time-study department, the primary duty of which, in its infancy, was to arrive at a fair rate of production per unit of time. It was then, as it is now, the object of the manufacturer to establish and maintain a more or less definite labor cost; but the cost, as determined by a time-study, was approximately the cost of manufacture of a given article for a considerable length of time after it was put into production, unless some drastic action was taken immediately to reduce the time by using new machines and tools. It should be noted that the cost was obtained after production had started and after tools and machinery had been made. Use of the control budget, or predetermination of all controllable expenses such as non-productive supplies, non-productive labor and other miscellaneous expenses for a given production, was the next progressive step. Up to this time almost every other item except productive-labor costs, the largest single item of cost, had not been budgeted before production had started.

In attaining a predetermined labor-cost, the time-study department plays an important role, and the method used by the Continental Motors Corporation, by which labor costs are successfully budgeted within the range of expectancy, with the assistance of the time-study department, is presented herewith.

Method of Predetermining Labor Cost

When a customer wants an engine having a performance capability different from that of any engine we are building, the engine is designed either by the customer's engineers, by our engineers, or as a result of their combined efforts. After the drawings are approved by the engineers, they are turned over to the manufacturing-department committee, together with a statement of the estimated daily production required. This committee, on which is a representative of the time-study department, discusses tools, equipment, methods and labor costs, and makes comparisons with other models. The labor cost is budgeted after careful analysis in which tools, equipment, comparison with other models, and the following time-elements on every part are considered in the sequence in which they are to be performed:

(1) Picking up or handling the piece to be worked
(2) Clamping or chucking
(3) Approaching and engaging feed
(4) Cutting time
(5) Disengagement and return of tool
(6) Unloading and handling
(7) Allowances for tools, fatigue and the like

The determination of the time needed to perform operations (1) to (3) inclusive is the result of the experience of the time-study men. The cutting time, element (4), is determined from charts of speed and feeds. Elements (5) to (7) are timed according to the machine and the nature of the work. From the consolidation of these elements the time per operation is determined and the total price per piece is set. This rate is then submitted for the approvals of the management, the production engineer, and the superintendent. The time-study department issues a routing, showing the sequence of operations and the machine equipment as decided upon by the manufacturing committee, to the tool-design department for its guidance in designing tools.

When new parts are to go into production, a meeting of the department foremen is called by the superintendent with a view toward getting the fullest cooperation in meeting the budgeted prices. These prices are effective immediately after each operation has been set up according to the tool set-up sheets, and the work performed is approved by the inspection department. A very important function of the time-study department then begins.

The time on each operation is checked to determine whether the job, as it is running in production, is taking longer than the predetermined time. When this check shows a greater total time than that which was estimated, an elementary study of the job is made. In most cases, the time-study man can suggest something to the proper authority which will make it possible to perform the operation within the specified time. Our experience shows that very appreciable savings in both time and effort are the result of these suggestions, and at a relatively low cost of attainment.

Among the observed impediments to production we

[1] Manufacturing division, Continental Motors Corporation, Detroit.

have, primarily, the handling of material. This is a major consideration in many cases which brings about high labor-expense, especially when it is remembered that a machine-tool which is used on the particular operation may be of great value. Therefore, small conveniences such as counterbalancing devices, small tables, chutes, more accessible controls and a handier place in which to store the work after the operation is completed, enable us to get more production per day automatically with no more effort on the part of the operator and with the same machine-tools. Our time-study men are instructed to watch for these things.

Speeds and feeds are checked when the time of the operation is below the budget figure, and it is usually a simple matter to have them corrected when they are found to be wrong.

Advantages and Results of Time-Study

A major advantage of the method outlined is that, when the time has been estimated previously for an operation, it is only necessary to get the over-all floor-to-floor time on operations until one is found which is in excess of the allotment when making a time-study check in the shop. This system makes it possible to get production jobs on a paying basis in less time than is customary in many plants, because the rate is on the job at the time it starts and this saves thousands of dollars in our launching expenses. It is also possible to accomplish all this with a small force of time-study men.

Another very decided advantage of this system of having the piece price on the job at the time production starts is that an incentive is given at once to the operators to start work at a rapid rate of speed. This has an obvious advantage over the method of waiting until the operation is timed before a price is assigned to an operation or job. Having rates on each piece at the time production starts makes it easy for the management to pick out the departments or groups which should be given first consideration or help in eliminating the reasons for costs above the estimate. When a group which is not earning the desired wage is found, from the wage sheet which passes through the time-study department for a careful analysis before payment is made, a report is made to the management. This report is kept up daily as long as is necessary and shows the progress being made in overcoming the obstacles and increasing the earnings of the operators.

The fullest cooperation between operators, foremen, superintendent, and time-study men is very essential under this system, and conditions are improved by the system to the point at which we all "talk the same language." Everyone is familiar, on the contrary, with the friction that the time-study man usually meets in setting rates from observed performance.

Cooperation is certain to bring results in any enterprise. Setting rates before production starts has made it possible in the last year for us to produce units at a budgeted labor-cost within 1 month after production has started; whereas, in the past, it has taken from 5 to 6 months to produce engines at a cost which we considered right for the unit.

Competition for the Consumer's Dollar

IN modern business we hear much of competition. Even the automobile business, in spite of the great desire for individual transportation which most people have, is finding it harder and harder to sell motor-cars and after-market products and service.

While we have competition within each trade, it is not so much a competition among individuals as it is a competition of methods. There is a vast competition today among industries. The "consumer's dollar" will go only so far and every industry is as much interested in getting that dollar as we are. We contend, therefore, with two forms of competition; first, the competition among industries and, second, the competition among methods in each separate industry.

The competition among merchants is what I call competition among methods. The public is interested in but one thing, the ease with which it can buy. We are interested, primarily, in two things: The development of better selling methods and of greater markets for the products of the automotive industry.

We have still another form of competition, which is the competition existing between Europe and the United States. We have learned how to produce in large quantities. Europe has been slow to learn this lesson but now has commissions over here in almost every line of business, studying our production methods so that it can do likewise and take some of our markets away from us.

Improving Automotive Service and Market

These are problems which are definitely before many men who are making a bid for the customer's dollar today. Every automotive merchant should be keenly alive to it. Other industries do not take gracefully the billions of dollars which the American public is investing in automobiles, equipment, supplies, and service. What are we doing toward maintaining our position? What are we doing toward improving our service to the public? What are we doing toward meeting the modern trend of business by making it easy to buy through better methods of dealing with the public? What are we doing to enlarge our markets and offset the salesmanship and propaganda which are being trained upon us in an effort to reduce our volume of business?

We are concerned with the general development of markets and methods and with ways and means of reaching those markets and of adopting those methods. There are but two ways of increasing business profit; one is by the increase of sales and the development of markets and the other is by the elimination of waste.

Various industries are spending millions of dollars in finding new methods of merchandising and in presenting them to merchants in their particular lines of industry. In the race for the consumer dollar, the automotive industry, having put forth no concerted effort for the purpose of developing its markets, is shown as a poor second. Other industries have spent $30,000,000 for greater-market development. As a matter of fact, this amount of money was spent by groups within one single industry. The expenditure by all industries during the last few years amounts to hundreds of millions of dollars.

We speak of the consumer dollar when, as a matter of fact, this dollar has shrunk to 20 cents after necessities, such as rent, food and clothing, are paid for. The automotive industry, therefore, is in competition with a great many other industries for the sole purpose of getting its share of the 20 cents remaining after the consumer has bought the necessities of life.—From an address by Harry G. Moock, managing director, Greater Market Development of the Automotive Equipment Association.

Development of the Automotive Diesel Oil-Engine

By C. L. CUMMINS[1]

INDIANA SECTION PAPER *Illustrated with* PHOTOGRAPHS AND DRAWINGS

Starting with Dr. Diesel's experiments, a brief outline of Diesel-engine development is given.

The various types of fuel injection are classified and briefly described, with summaries of their several advantages and disadvantages.

Steps in the development of the Cummins oil-engine are given, with a statement of the objects sought in the design and a description of the construction and operation of the injector mechanism developed to accomplish those objects.

In this mechanism oil at low pressure is admitted to a small chamber near the point of the injector, where it is heated during one cycle of the engine. The fuel charge is then transferred to a second chamber where it is vaporized by compressed air from the cylinder. Combustion occurs when the vaporized charge is injected into the compression space of the cylinder.

THIS paper is to tell the story of oil-engine development from the viewpoint of a man who must build a product that will fit the needs of the customer and that must be sold at a profit, rather than from a technical viewpoint. I believe that engineers should give more attention to the practical and commercial sides of their problems.

Diesel-engine history dates back to about 1892, when Dr. Diesel, a German engineer, made his first experiments on and disclosures of an engine originally conceived and developed to use pulverized coal. His early experiments were centered upon the idea of a measuring device which deposited a charge of pulverized coal into a receptacle located in the cylinder-head and then blew, or injected, this charge into the combustion-chamber, where compression was carried to a pressure sufficiently high to develop ignition temperature. As this was not very satisfactory, Dr. Diesel substituted liquid fuel for dry fuel and soon had an engine that ran sufficiently well to warrant further development.

Because of the poor commercial distribution of oils and the low cost of other fuels, the Diesel engine advanced very little until about 1902. Thereafter its use grew gradually until about 1915 or 1916, when development began to increase rapidly, especially in the smaller sizes which were almost unknown until about 1916.

Since oil engines became commercially practical, innumerable methods of fuel injection have been brought out, but nearly all that have been in use to any extent by the public may be classified in the following general types: (*a*) air-injection, (*b*) solid-injection, and (*c*) gas-injection. As the type that forms the main subject of this paper does not readily fall into any of these classes, we may add (*d*) Cummins injection.

LARGE ENGINES USE AIR INJECTION

Since practically all of the large Diesel engines, some of them as large as 18,000 hp., have employed air injection, this type has been used more generally than any of the others. Its principal advantage is that the fuel is thoroughly broken up and well distributed through the combustion-chamber by the high-pressure air used for injection and by the resulting turbulence. Other advantages are a slight gain in power because the injection air is added to that already compressed in the cylinder, and the possibility of controlling the pressure in the cylinder to a considerable extent by the influence of proper air-control on the rate of admission of fuel into the combustion-chamber.

A chief objection to this type is that the production of compressed-air at pressures of from 800 to 1500 lb. per sq. in. is costly, requiring excellent two or three-stage compressors, extremely heavy air-lines and expert attention. Perhaps a more serious objection is the power required for compressing the injection air. This is seldom less than 5 per cent, and sometimes as high as 15 per cent, of the total output of the engine. The average is probably 8 or 10 per cent.

Expansion of the injection air as it enters the cylinder causes a cooling effect that is said by some to be nearly sufficient to deliver the fuel in the form of frozen globules. This lowers the temperature of the compressed charge and delays combustion, and at light loads sometimes causes the engine to misfire and even to stop. As compressor power remains nearly constant, a considerable decrease in efficiency results as the load is reduced. Owing to the mechanical complication, this type is suitable only for comparatively large cylinders.

VARIOUS TYPES OF SOLID INJECTION

Engines using solid, mechanical or airless injection are widely used in sizes under 1000 hp. They may be divided into five classes:

(1) Engines of the first and oldest classification of this type use surface ignition, with a bulb or tube heated externally for starting. Compression pressure in these engines is only 120 to 150 lb. In most cases the charge is throttled between the combustion-chamber and the heated bulb. Such engines have been very useful, but they give poor economy and are suitable only for constant speeds and loads. The nuisance of heating the bulb or tube by means of a torch

[1] A.S.A.E.—President and general manager, Cummins Engine Co., Columbus, Ind.

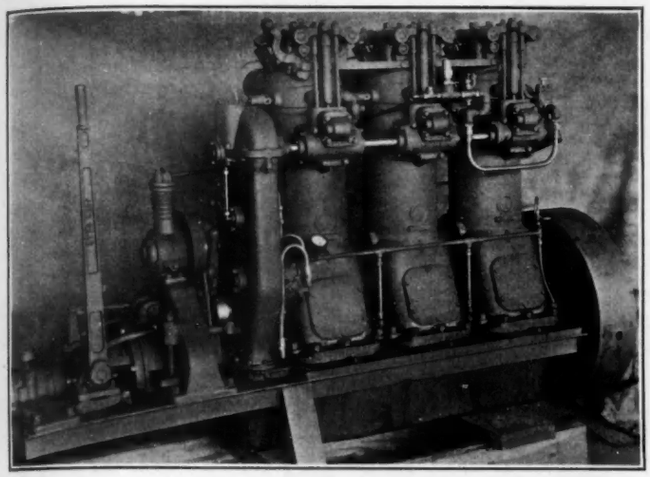

FIG. 1—CAMSHAFT SIDE OF CUMMINS MARINE ENGINE

This Engine Is Supplied with Fuel by the Common Pump Shown in Fig. 4, Which Delivers Oil at Not More Than 60 Lb. per Sq. In. to a Fuel-Measuring Valve in Each Cylinder, as Shown in Fig. 5

or electric plug has injured the popularity of this type

(2) With medium compression-pressures of about 350 lb. per sq. in., charges of fuel are injected by individual pumps either into the main combustion-chambers or into stifled bulbs or tubes. These engines are somewhat more economical than the low-pressure solid-injection type. Most engines of these two types operate on the two-stroke cycle

(3) With compression pressures as in the second group, a third type has a common pump that delivers fuel at from 1500 lb. to several thousand pounds pressure through a common feed-line and needle-valve-controlled sprays located in each cylinder. This type has been used more extensively during the last few years, almost entirely with moderately large cylinders, and gives better economy, cleaner exhaust and better regulation than the older types. It is subject to the serious objection of working on what is known as the time-pressure basis of fuel supply, which permits an overcharge of fuel when the engine is so much overloaded as to be slowed down below its governed speed. This cuts the lubricating-oil from the cylinder-walls and causes high temperature in the exhaust gas because of slow burning, with detrimental effect on the exhaust valves. The practically instantaneous feeding of the charge into the cylinder causes a considerable rise in pressure above that caused by the compression. It is therefore customary to avoid compression pressures above 350 lb., below which pressure starting has not been dependable

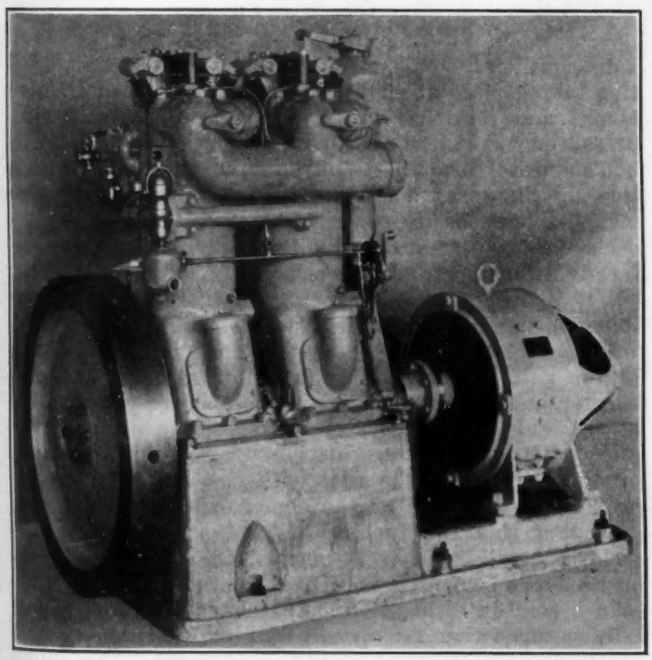

FIG. 2—EXHAUST SIDE OF ENGINE-GENERATOR SET

Fuel Injection in This Engine Is Similar to That in the Engine Shown in Fig. 1

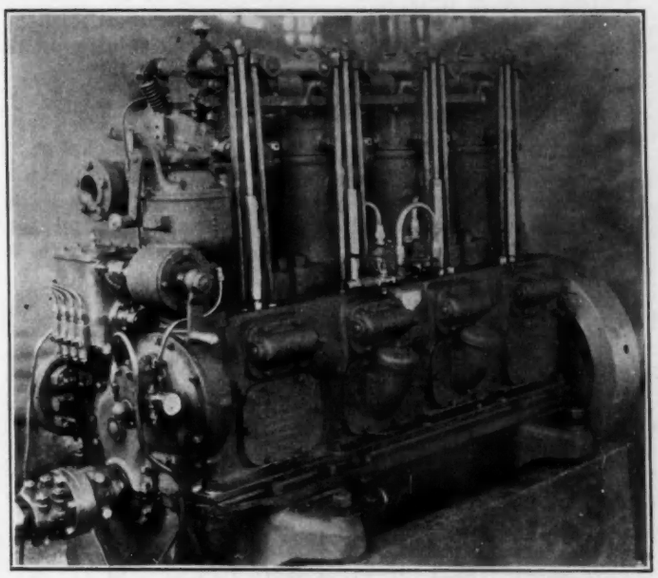

FIG. 3—FOUR-CYLINDER ENGINE FOR CONTRACTOR'S EQUIPMENT

This Engine Is Supplied with Fuel by a Pump Having an Individual Plunger for Each Cylinder, Feeding through the Check-Valve Shown in Fig. 7

(4) To raise the economy and to assure reliable starting, a type has been developed that uses about 500 lb. compression-pressure with two-stage combustion. The charge is injected into a separate chamber, connected to the cylinder proper through a restricted port of suitable size, by means of an individual pump for each cylinder, which develops sufficient pressure to operate a spring-loaded needle-valve. As the air contained in the chamber is insufficient for complete combustion, the fuel burns first to carbon monoxide and continues to burn during the power stroke as the contents of the chamber mix with those of the cylinder, where there is sufficient air for complete combustion. This after-burning causes heat losses and high exhaust-temperature. In spite of the relatively high compression, starting is rather unreliable. There seems to be a heat loss in transferring the air to the precombustion chamber or in evaporating the fuel which lowers the temperature to a point where ignition becomes uncertain. Because of this, chemically loaded cartridges of some fast-burning material are intro-

duced into the primary chamber at the instant of starting to add sufficient heat to assure ignition

(5) Other engines carry high-compression and use extremely high pressures on the fuel oil, which is delivered by a common pump feeding to all the cylinders

There are numerous mechanical objections to any method of injection that calls for high pressure on the fuel, whether furnished by a common pump or by individual pumps. The excellent design and workmanship required for such pressures can be controlled by the manufacturer, but servicing is not in the manufacturer's hands. Fuel oils usually contain fine sand or other dirt held in suspension, which, with additional dirt from containers, funnels and tanks, may cause trouble in the pump valves, overflows and by-pass valves. In some instances valve-seats are sandblasted until leakage affects the efficiency of the engine. Centrifuging of the fuel can eliminate this to a large extent, but accessories such as a centrifuge are seldom available or practical for small engines operating in isolated locations.

Gas Injection Requires Light Fuels

The third classification is the gas or pre-explosion type, as covered by the Brons or Hvid patents. This method is suitable only for kerosene or extremely light fuels, as it depends upon vaporization of the fuel for preparation of the charge. As the flash-points of fuels vary considerably, the results are quite uncertain, ignition taking place at almost any point in the compression stroke and resulting in erratic and high combustion-pressures. Furthermore, in vaporizing heavy fuels, carbon deposits form in the injector mechanism and soon clog up the spray holes and either stop the engine or materially reduce its power. This type was, however, a decided improvement over the early low-compression surface-ignition type and was used for a number of years, but it is being succeeded rapidly by more modern types that will handle the heavier fuels.

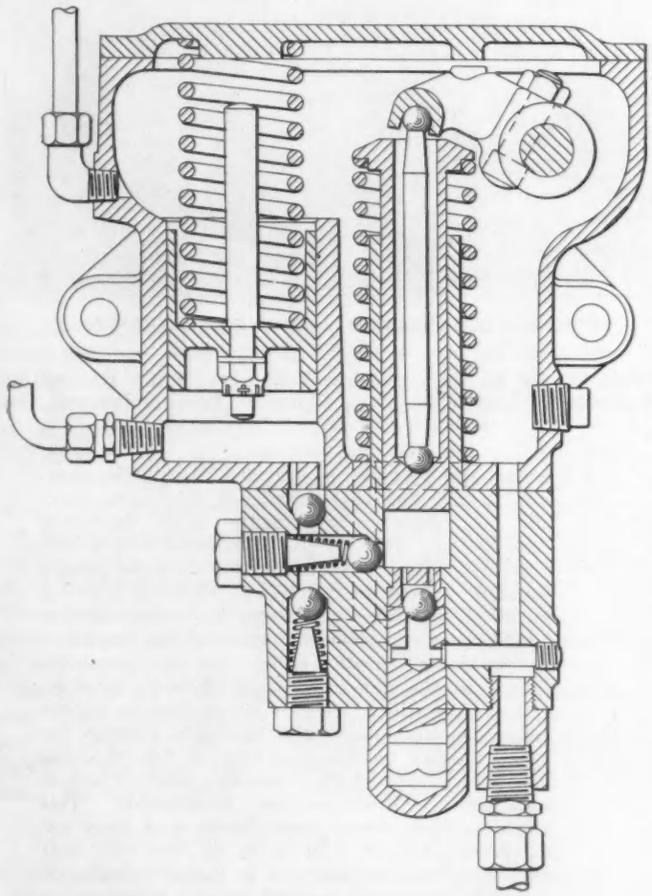

Fig. 4—Single-Plunger Fuel Pump

This Pump Is Used to Supply Fuel at Moderate Pressure for Several Cylinders. With This Pump Admission to the Various Injector Valves Is Controlled by Needle-Valves Like Those in Fig. 5

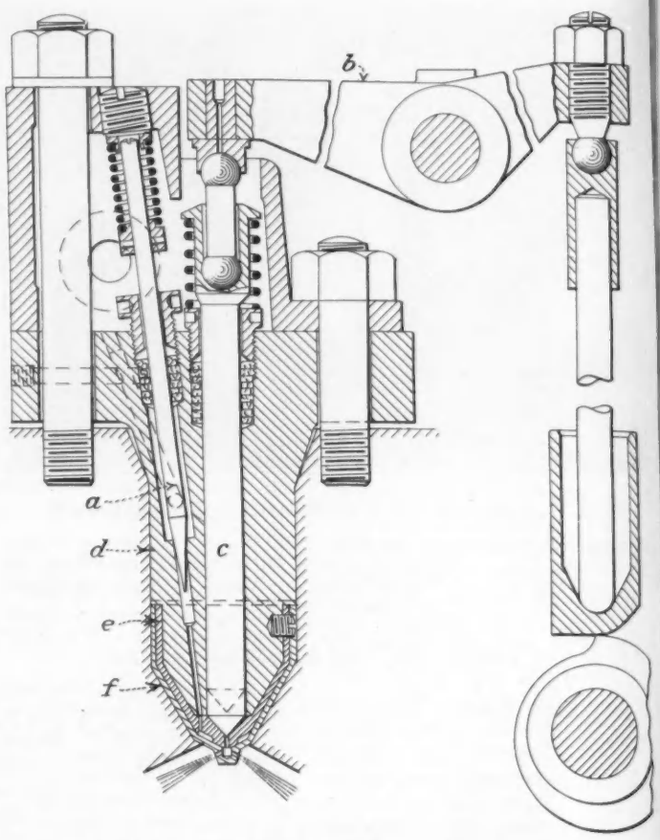

Fig. 5—Injector Mechanism with Metering Valve

Fuel-Measuring Valve *a* Is Operated from Timing Lever *b* by a Small Lever, Not Shown, Which Makes a Contact with the Collar at the Lower End of the Spring. Injection Plunger *c*, also Operated by Lever *b*, Is Shown in Its Position at the End of the Injection Period. Atomizer Housing *d* Is Assembled with the Inner Fuel-Cup *e* and Outer Fuel-Cup *f*, Containing the Spray Nozzles Which Are Shown More Clearly in Fig. 6

Proper preparation of the fuel is a prime essential. In the gasoline engine this is the function of the carbureter, and appreciable time is available for vaporization before ignition occurs. Since compression in an oil engine is made high enough to assure ignition, it is not practicable to mix the fuel with the charge until approximately the end of the compression stroke. It is important that the fuel be injected at a point in the cycle that will cause it to burn at the time when combustion will be most efficient.

In a solid-injection engine the charge has only about 1/50 as much time for vaporization and burning as in a gasoline engine running at the same speed. This limits the speed of oil engines to 800 or 900 r.p.m., or to 600 to 700 r.p.m., according to some authorities. When operated at higher speeds the fuel consumption increases

and the exhaust temperature is higher, unless the injection timing is advanced, with the possibility of causing excessive pressure. In the various solid-injection engines the injection period ranges from 2 or 3 deg. to 8 or 10 deg. As the fuel has had no preparation before injection, considerable time-lag results with injection of this sort.

Desirable Characteristics Listed

Personal experience, gained in building a large number of engines of some of the types already described, established certain fundamentals as desirable to secure a practical engine. For small high-speed light-weight engines, in which we were primarily interested, the following features are desirable:

(1) Pressures in the combustion-chamber must be under perfect control

(2) The fuel must be carried under very low pressures and in a simple and practical manner

(3) Metering and throttling of the fuel must be done in such a way that the engine can be operated for long periods at extremely low speeds

(4) There must be no trouble from formation of carbon in the injector mechanism

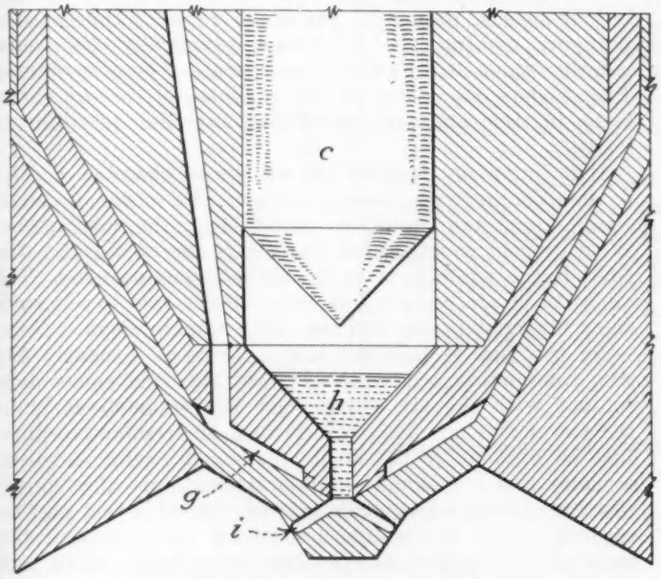

Fig. 6—Sectional View of Nozzles

The Fuel Is Pre-Heated in Annular Space *g*. It Is Then Transferred to Chamber *h* through Six Notches at the Lowest Point of the Inner Fuel-Cup and through the Vertical Passage. Near the End of the Compression Stroke a Small Portion of the Air Charge Is Forced Up through the Fuel Nozzles *i* and the Vertical Passage To Vaporize the Fuel in Chamber *h*. The Vaporized Charge Is Injected by Plunger *c*

(5) The engine must show economy equal or superior to that of others

(6) Higher mean-effective-pressures should be obtained, thus lessening the cost per horsepower and reducing the bulk of the engine sufficiently to make it applicable to any service in which gasoline engines are commonly used

(7) The method of injection must make possible thorough preparation of the fuel, to enable the engine to operate at high speeds

(8) The engine must start instantly under the worst weather conditions and must be so simple and fool-proof that the average person can install and operate it with no more instructions than can be given in a simple instruction-book

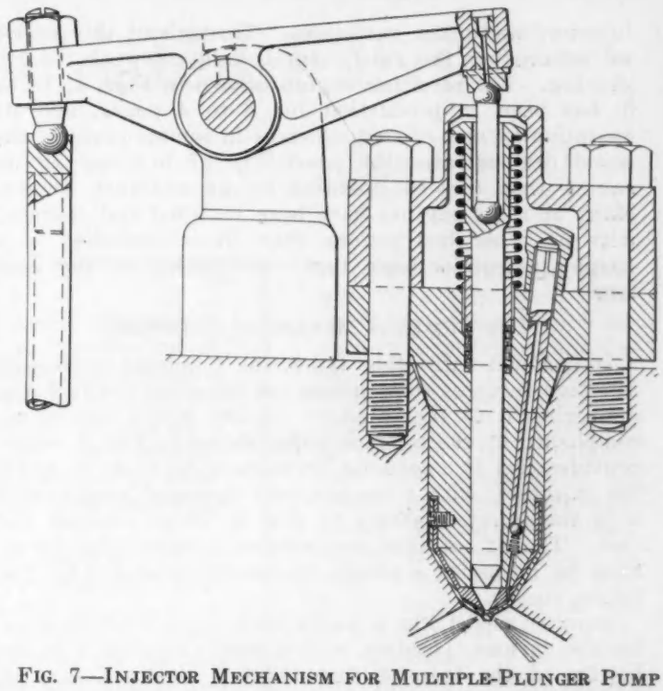

Fig. 7—Injector Mechanism for Multiple-Plunger Pump

No Fuel-Measuring Valve Is Required. Fuel Is Delivered through the Small Ball-Check-Valve Near the Lower End of the Injector Housing

During a development period of nearly 5 years we designed, built and thoroughly tested engines of six distinctly different designs, with hundreds of different

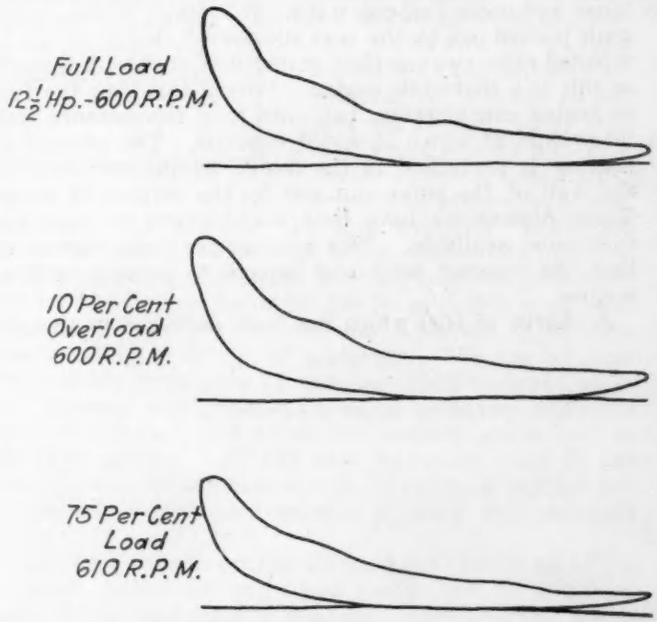

Fig. 8—Indicator Cards from Cummins Engine

The Full-Load Card Represents 12½ Hp. at 600 R.P.M. from a Cylinder with 5½-In. Bore and 7½-In. Stroke. The Combustion Line Is Somewhat Higher in the 10-Per-Cent-Overload Diagram, Especially at the Left End, Showing the Effects of Earlier Fuel Admission. In the ¾-Load Card the Effect of Later Injection Is Shown by the Fact That the Combustion Line Is Lower than the Highest Point of the Compression Line

injectors and other variations. Throughout this period we adhered to the fundamentals laid down at the beginning. The resulting engine, shown in Figs. 1, 2 and 3, has been in production for 3 to 4 years, and its operation by men of various races in remote parts of the world demonstrates the possibility of building an oil engine that can be operated by an ordinary person. Many of these engines have been installed and operated with no other instructions than those contained in a simple instruction-book that was mailed to the customer.

The Cummins Method of Injection

In common with other types, the Cummins method of injection requires some means for metering the fuel and delivering it to the injector. In one model this is accomplished by the common pump shown in Fig. 4, which provides fuel at a constant pressure of 30 to 40 lb. to all the injectors, with a mechanically operated needle-valve *a* in the injector, shown in Fig. 5, which controls the fuel. The lift of this needle-valve is varied for throttling by means of a simple mechanism operated by the intake rocker.

Another model has a pump with individual plungers for the various cylinders, with a small check-valve in the bottom of the injector instead of a needle-valve. As fuel is delivered to the injector during the suction stroke of the engine, the pump has to overcome only the resistance of the fuel line and of the small check-valve, which requires a pressure of only 50 or 60 lb. per sq. in. This eliminates trouble from air-pockets, which are troublesome with high-pressure injection, particularly where individual pumps and hydraulically operated spring-loaded needle-valves are used.

After passing the check-valve or needle-valve, the fuel stands in annular space *g* shown in Fig. 6, between the inner and outer fuel-cup walls. It remains in this space until pushed out by the next succeeding charge, which is injected after two complete revolutions of the crankshaft, as this is a four-cycle engine. During this time the fuel is heated considerably, but only to a temperature well below that at which it would vaporize. The amount of heating is controlled in the design by the thickness of the wall of the outer cup and by the volume of space. These dimensions have been standardized to suit the fuels now available. This arrangement also serves to keep the injector point cool enough to prevent carbonization.

A charge of fuel which has been delivered to the annular space *g*, in Fig. 6, during one suction-stroke of the engine remains there during the compression, power and exhaust strokes. During the next suction-stroke it is pushed by the succeeding charge through a series of small notches into the conical lower end *h* of the plunger chamber, where it stands in a pool directly over the spray nozzles *i*. During this transfer, plunger *c*, Figs. 5 and 6, is being raised slowly, thus preventing the fuel from entering the cylinder during the suction-stroke. In Fig. 7 is shown the simpler injector-mechanism used with a pump having one plunger for each engine cylinder.

During the compression stroke a portion of the heated and compressed air from the cylinder is driven through the spray nozzles *i*, Fig. 6, and through this pool of fuel, thus vaporizing the fuel and preparing it for injection. Approximately at top center the plunger is depressed, forcing the charge of vaporized fuel through the distributing nozzles in the lower end of the conical chamber and into the heated air in the combustion-chamber.

Charge Burns Faster at High Speeds

Injection is controlled by the shape of the cam, which injects the fuel as fast as it can be burned without an appreciable rise in pressure. Indicator diagrams taken at various speeds show that the burning is faster at high engine-speeds, owing to the more rapid action of the plunger, making the diagrams practically the same whether made at high or at low speeds. The diagrams in Fig. 8 show the effect on the combustion line of variations in time and amount of fuel injection at different loads.

It is important to keep the volume of chamber *h*, Fig. 6, small, otherwise enough oxygen will enter to allow combustion, and result in carbonizing the mechanism. With present construction, the air is forced through the fuel charge while it is at its highest temperature. The quantity of air required to vaporize the fuel is not sufficient for combustion, and the parts remain clean.

As the fuel is injected in the form of a nearly dry gas, combustion occurs the instant the fuel comes into contact with the air charge and is completed early in the power stroke. This results in a mean effective pressure as high as 90 to 130 lb. per sq. in., with excellent economy and low exhaust-temperature. This high mean-effective-pressure has made possible portable and marine engines within the weight and space limitations of the usual gasoline engine of the same horsepower rating, and we believe that oil engines can be made lighter with this method of injection than with any other in use at present.

Cellulose-Nitrate Coated Fabrics

By E. H. NOLLAU[1]

DETROIT SECTION PAPER

"Coated fabric" is a better designation than "artificial leather" or "leather substitute" for much of the material that is produced today and used so extensively in the automotive industry. It is not merely a low-priced substitute for real leather; tests have shown that, regardless of lower cost, it is preferable to other materials for some purposes.

Much harm has been done to the industry by misuse of the material, however, and great need exists for education of the consumer in its proper use. Often the consumer is impatient to use the material before it is known how satisfactory it will be in the service to which he desires to put it. He should rely upon the recommendations of the manufacturer of the material, and close cooperation between the producer and the consumer should be established.

The author, a recognized authority on the subject, names the materials used for base and coating and describes in detail the processes of manufacture. Both the raw materials and the finished goods are subjected to rigid tests for quality. Obvious need exists for standardizing the product.

THE product which is the subject of this paper is variously referred to as artificial leather, leather substitute, or perhaps more generally, coated fabric. The terms "artificial leather" and "leather substitute" were more nearly correct in the early years of the industry, because the product then manufactured was a material to simulate genuine leather not only in appearance but in durability and wearing qualities. In recent years, however, modifications have been introduced and the general type of material lent itself admirably to production in various combinations and color schemes, so that much of the product that is made today and that will be made in the future is better designated as coated fabric, or perhaps still more generally, coated textile. Various manufacturers market their products under trade names that are familiar to the consumers.

Artificial leather is not merely a low-priced substitute for real leather. Tests have shown that in many instances it is to be preferred to other materials, even disregarding the cost advantage. Much harm has been done to the industry, however, by misuse of the material, and great need exists for education of the consumer by the manufacturer in the proper use of the material. The producer should know from his manufacturing experience and his development work whether the material will be satisfactory for the use intended by the consumer Therefore the consumer should trust the advice and recommendations of reliable manufacturers and not demand material the serviceability of which is questionable. New conditions of use are arising constantly, and the manufacturer must meet these. It is also the manufacturer's aim constantly to improve the quality of his product. To do this it is necessary to have a competent technical staff constantly working on the product. This requires the expenditure of considerable money, as a responsible manufacturer stands back of his product and wishes to maintain his standing in the industry. He often loses business temporarily to gain time to conduct necessary tests on a new product or to test a standard product for a new use. The consumer in many such instances is impatient and desires to use the material without knowing exactly how satisfactory it will be in service. It is evident that close cooperation between producer and consumer should be established and encouraged, so that both may profit; the former by extending the use of his material and the latter by obtaining always a satisfactory product for his new needs.

MATERIALS USED IN MANUFACTURE

Manufacture of artificial leather seems simple from the description but it actually involves considerable detail which must be controlled closely. Essential raw-materials used are cotton fabrics of various kinds; cellulose nitrate; organic solvents, such as denatured alcohol, butyl acetate, ethyl acetate and aromatic hydrocarbons; softeners and plasticizers; and pigments. To produce the approximately 18,500,000 sq. yd. of coated fabric used in the automobile industry in 1923, the manufacturers used approximately 14,000,000 lb. of base fabrics, 2,100,000 lb. of cellulose nitrate, 12,100,000 lb. of organic solvents, 4,500,000 lb. of softener, and 1,700,000 lb. of pigments. The use of such tremendous quantities of raw materials requires careful physical and chemical control to assure that the finished product will be of the highest grade and of uniform quality. All the raw materials used in the manufacture of the best brands of artificial leather are subjected to rigid and careful physical and chemical tests.

The base fabrics ordinarily used are sheetings, drills, sateens, moleskins, or broken twills, and, to some extent, ducks and similar weaves. Sheetings and ducks come under the general heading of plain-weave fabrics, whereas the others come under the heading of twill weaves. In the plain weaves the warp and filling threads interlace with perfect regularity; that is, the warp thread passes alternately over and under a filling thread, and the filling thread passes alternately under and over the warp threads.

Sheetings are used for the lighter products and also to a large extent in the manufacture of double-texture

[1] Chemical superintendent, E. I. du Pont de Nemours & Co., Newburgh, N. Y.

goods, in which they usually form the portion of the finished material which contains the coating; that is, the upper part.

Weaves of Base Fabrics

Twill weaves have a more or less pronounced diagonal line. In the drills the intersection of the warp and filling threads produces ribs extending diagonally across the fabric. This effect is produced by passing a filling thread over two or more warp threads and then under one. When it passes over two warp threads and under one, the fabric is known as a three-leaf drill. If the filling thread passes over three warp threads and under one, the fabric is called a four-leaf drill.

In the case of sateens the diagonal line is eliminated to a large extent by the use of finer yarns and closer construction. This gives the material a smooth satiny appearance. To accomplish this, a large number of warp threads is necessary and the filling threads usually pass under several, often four, and over one. Moleskins or broken twills are very similar to sateen except that the material is heavier and the filling threads are more numerous than the warp threads, whereas in the sateens the reverse usually is true. In the moleskins and broken twills the yarns usually are not so tightly spun, which makes the finished material softer. This renders it easy to nap the back of the fabric, which is desirable for some uses.

When the base fabrics have been thoroughly inspected, they usually are dyed, or in some cases bleached. Dyeing gives the goods a more pleasing finished appearance and is accomplished by the ordinary jig or padder dyeing. The heavier materials, such as moleskins and broken twills, are often napped. This is done by a special machine and produces a mat of loose fibers on the back. In some cases, particularly in the heavier-weight materials, it is desirable to soften the fabric before dyeing. This is accomplished by soaking the material in a solution of diastase, which converts the starch of the sizing in the fabric into soluble products, then removing the soluble products by repeated washings.

Preparation of Coating Composition

Cellulose nitrate, which forms the base of the coating composition, is dispersed, or dissolved, in the organic solvents. This is done in large tanks, the contents of which can be agitated mechanically. The cellulose-nitrate composition or jelly usually is made in batches of from 10,000 to 20,000 lb. It resembles in appearance a clear gelatin solution. After proper screening and filtering, the cellulose-nitrate jelly is carried to storage tanks for mixing with the pigment and plasticizers or softeners.

The pigments, which are received in a dry condition, cannot be added satisfactorily to the jelly in this state. In common practice they are ground with the plasticizers or softeners, the most common of which is a very pure grade of castor-oil. The pigments usually are dispersed in a vehicle by grinding on standard three-roll paint-grinders, burr-stone mills or, in some cases, ball or pebble mills. The various basic pigments are ground separately, then mixed in suitable proportions to give any desired color or shade. Color matching and preparation of various compositions constitute an important part in the manufacture of the coating composition and require careful supervision and control. When the desired color is obtained, the pigment paste is added to the cellulose-nitrate solution and the mass is suitably agitated in a closed vessel to assure thorough dispersion of the pigment and softener or plasticizer in the cellulose-nitrate jelly.

The colored coating-composition is now ready for application to the fabric. It is applied by means of a doctor knife, under which the goods pass in the coating machine on their way into a drying chamber. The composition lies in a roll or puddle in front of the knife and, as the goods travel underneath, a thin film is applied to the fabric. This process is repeated as often as is necessary to produce the desired thickness of coating on the particular material that is being manufactured. The goods are coated in rolls ranging from 200 to 2500 yd. in length, the length depending to some extent on the weight of the fabric. After the desired amount of coating composition has been applied, the material presents a smooth but unfinished appearance. In this condition it is inspected for major imperfections and yardage and is then ready for the embossing operation.

Embossing and Two-Tone Finishing

Embossing imparts a specific design to the surface and improves its appearance. The designs are either reproductions of leather grains or in many cases are merely conventional designs. In the embossing operation the smooth-coated material is passed through heavy embossing-machines, which may be of either the roll or the flat-bed type. Embossing in the flat-bed machine subjects the material to rather high pressures at a temperature of about 250 deg. fahr. After this operation, the material that is to be shipped in a solid color is ready for a final rigid inspection.

In many cases it is desired to apply a finishing composition either of the same color as the base composition or of a contrasting color. This is often done to produce Spanish or two-tone finishes that duplicate those applied to genuine leather. Frequently multitone effects are produced in which conventional embossing-designs are used. These materials do not resemble genuine leather but are pleasing in appearance and find many uses.

The variety of grains, colors, shades and finishes in which artificial leather or coated fabrics can be manufactured is practically without limit. Our records contain between 4000 and 5000 colors and shades, and the number is increasing constantly. We have about 125 different grains and dozens of finishes.

Materials and Finished Product Tested Rigidly

All finished material is given a final rigid inspection before shipment. The same careful attention is given to the finished product as to the raw materials to maintain a high standard of quality. Quality usually is considered from two angles: First, as to the general appearance of the material with regard to color, finish and uniformity, with certain allowable variations, and also with regard to the feel and pliability; and, secondly, as to the initial quality of the coating on the fabric and, what is perhaps most important, the durability of this coating. The ideal test is a real service test, but this is not always practicable, although progressive manufacturers are continuously conducting service tests as part of their control work on the finished product. To obtain quick results, accelerated tests have been developed. To make these tests of real value, every effort has been made to interpret the results, so far as possible, in terms of actual service. The conditions to which the material is subjected in the test

should be as nearly as possible like those to which the material will be subjected in actual service. Exact duplication is not possible, as in general the conditions must be more severe in an accelerated test.

Obvious need exists for standardizing a commodity which has such extensive uses as artificial leather. The automobile manufacturer hardly can be expected to be conversant with all the details of the construction of the material and its general physical properties. Through failure to have this information available, the consumer may pay more than is necessary for the type of material he needs for a particular purpose. Matters of importance to the consumer are: total weight of the material per square yard; weight of the coating material; and weight, count and construction of the fabric. These data can be secured by comparatively simple analyses which the consumer himself can make if he desires. Other tests can be made by the manufacturer in the regular control-work on his product during the manufacturing process.

THE DISCUSSION

QUESTION:—Could these materials be used satisfactorily as a body covering, in place of the usual sheet metal?

E. H. NOLLAU:—They are used to some extent in Europe and have been used in this Country, but not to take the place of steel. About 1917 the company with which I am connected developed what it called the California top, which was a permanent top on an open car. The top was a cellulose-nitrate material, and the entire body was covered with this material, which was entirely satisfactory. I know of one car that had been used for about 8 years and, when properly polished after that time, looked almost as good as new. I know of no reason why the material cannot be used as a body covering if the right type of material is employed. It is used in this Country by the Fabric Body Corporation. The best test it has had is in connection with the California top, which was much in vogue on the Pacific Coast before the advent of the closed car. Several types of fabric-covered bodies were exhibited at the New York Automobile Show in January, 1927.

QUESTION:—What has the color to do with the aging life of the material? And would not the same coating on leather exhibit the same properties as if coated on fabric?

MR. NOLLAU:—Judged by the heat-aging test, we find that for some unknown reason there is a very slight difference between color and black. So far as the different colors are concerned, we have been able to find no difference with respect to aging. As to putting the cellulose-nitrate material on leather, that is actually done; split leathers are treated with a very thin coat of the composition. Actual tests have shown that the coated fabric is preferable to poor splits.

Right Use of Street Signals

STREET-SIGNAL timing causes much trouble. What loads streets will carry and at what speed they can be moved safely must be planned in detail before timing is adjusted. A competent engineer should advise on this before signals are installed. Shorter signal-intervals will speed traffic. The chief purpose of signals is to expedite, not hamper, the movement of traffic.

Signals should permit cars to move continuously. In most cities, 12 m.p.h. is all that can be expected in congested districts. Signals, made progressive instead of synchronized, should be timed to permit that speed. Every signal ought to bear a sign telling at what speed they are set, so a person will know how fast to drive to be able to go continuously. That would curb the speeder, too.

Progress through streets is choked by loading and unloading at curbs, by pedestrians, taxicabs, and a dozen other factors that cannot be prevented. On Fifth Avenue in New York City, the average speed is 5.0 m.p.h.; for motorcoaches it is 2.6 m.p.h. In Chicago's Loop it is 11 m.p.h.; that is from 50 to 100 per cent faster than it was 3 years ago. At State and Madison Streets, at the busy hour 1100 persons pass from curb to curb every minute. If they were made to wait for traffic signals, they never would get across; there is not temporary storage space on the walk to accommodate them while waiting. If a person is alert enough to be in the Loop at all, that person is alert enough to move from curb to safety zone, or all the way across the street, without having to wait for traffic. They must be allowed to sift through traffic, there are so many of them. That is a situation which is peculiar to that section; it would not apply somewhere else.

Synchronized lights, causing cars to stop, defeat the purpose for which signals are established, which is to move traffic. On Michigan Avenue in Chicago the speed is from 10 to 12 m.p.h. and with proper lighting-timing, it should be from 20 to 24 m.p.h.

Often a caution-signal is better than a stop-go sign. It is folly to put a stop-go light where it will retard traffic and where it is useful only at short peak-hours.

Three lights are necessary to tell a driver adequately what we expect him to do. Red means "Stop at once and stay stopped." Yellow means "Get ready for a change"; every driver who does not heed the yellow sign ought to be arrested at once. The yellow light is abused and it causes most of our trouble because people are permitted to abuse it. They should be stopped every time. Most people have a mistaken idea about the green light. It does not give them an absolute right of way. It tells them, "Go ahead if you can," for there may be a through-street, a pedestrian or some other legitimate obstruction.

Most of our accidents result from lack of courtesy or consideration of other people. Many come from lack of adequate information. We must give it with our signs and signals. These should be uniform, so the resident of one city will know what to do in any other city.

The shorter the time-interval the better; 75-sec. cycle is the longest in Chicago. In many places this can be cut to a 50-sec. cycle. Three seconds of amber light is enough to clear crossings. Signal lights should be at the side, for they are more readily seen and do not impede traffic, in most places.—From an address by E. J. McIlraith at Chicago City-Traffic Conference.

Manufacturing and Testing Rubber-Coated Automobile Fabrics

By M. N. Nickowitz[1]

Detroit Section Paper *Illustrated with* Photographs and Chart

More than 13,000,000 yd. of rubber-coated top-material was produced in this Country in 1926, and, in addition, approximately 6,000,000 yd. of other types of material, including pyroxylin and oil-coated fabrics, was used for automobile tops. Principal ingredients entering into the manufacture of rubber-coated top and deck material are base fabrics, crude and reclaimed rubber, naphtha, sulphur, accelerators, antioxidants, inert fillers, softeners, and varnishes.

Methods of manufacture are much like those used in the production of cellulose-nitrate or pyroxylin-coated fabrics, and the types of fabric used and their preparation are similar. Processes of preparing the rubber compound, applying it to the fabric, varnishing the surface and embossing the material are described briefly.

The major part of the paper is devoted to detailed description of tests applied to the materials used and to the finished product to assure superior quality and serviceability of the material for the uses to which it is to be put. These include stress-strain tests on the rubber compound, both new and aged; scrub-tests of the coated fabric in a motor-driven scrubbing machine; accelerated aging-tests in an oven for 4 days at a temperature of 158 deg. fahr., by exposure to ultra-violet light, and by a new method of subjecting it to oxygen at a pressure of 300 lb. per sq. in. and a temperature of 140 deg. fahr.; fold tests in a motor-driven machine to determine the breaking end-point; hydrostatic tests to determine its permeability by water; anchorage tests to measure adhesion of the coating to the base fabric and the strength of combining of double-texture material; tests for sulphur blooming of the rubber; weather-exposure tests for 1 year; tests for resistance of the coating to cracking along the edges of folds; and analyses of the base fabric for structure and the rubber coating for weight.

Some of these tests can be made by the car or body manufacturer, but others cannot. It is hoped, however, that many of them will be applicable to work in the automobile plant and will be found of value. It is not necessary to employ all the tests in the case of a coated fabric for any specific purpose; the purchaser need only specify and apply those which indicate the qualities necessary for that purpose. Some of the tests can be written into the purchase specifications; others are of greater use in deciding what types or makes of top material are best.

Discussion brings out the fact that the du Pont company is working to develop an accelerated test to take the place of the exposure test; on a test to combine the effect of ultra-violet light with that of alternating heat and cold; and on the development of a serviceable colored-rubber decking-material. Relative desirability of rubber-coated and pyroxylin-coated fabrics for top material is also discussed; and blooming is said not to injure the aging quality of the rubber coating.

Although the automobile-top industry consumes only a small portion of the world's rubber supply, it produced more than 13,000,000 yd. of rubber-coated top-material in the year 1926. In addition, approximately 6,000,000 yd. of other types of material was used for automobile tops. These include pyroxylin and oil-coated fabrics.

The important ingredients that enter into the manufacture of rubber-coated deck-material are the fabric base, crude rubber, reclaimed rubber, naphtha, sulphur, accelerators, antioxidants, inert fillers such as whiting (calcium carbonate) and barytes, softeners like factice (vulcanized oils) and gilsonite, and varnishes.

In many respects the manufacture of rubber-coated fabrics is like that of cellulose-nitrate-coated fabrics, and the types of fabric used and their preparation are similar.

The preparation of the rubber compounds is of utmost importance. To produce the best type of material, this operation must be as nearly fool-proof as possible. Each ingredient has a definite function to perform, and omissions or substitutions are easily detected. The batches are weighed on precision scales which are checked periodically. The compounds are mixed in either of two ways: Black compounds, such as are used for carriage cloth, are mixed in large internal mixing-machines which are capable of mixing 900 lb. per hr. each, the temperature and time of mixing these compounds being carefully controlled by automatic recording-devices. Colored compounds and cements are mixed on steel-roll mills like that shown in Fig. 1, in which two polished-steel rolls run at different speeds.

After mixing, the compounds are strained through very fine screens, which remove any foreign particles that may have got into the compound during the mixing. The strained compounds are then sheeted and permitted to "rest" for 24 hr. so that the rubber will set and give a more uniform finished product.

How Coating Is Applied to the Fabric

The rubber compound is ready to be applied to the face of the fabric after it has been softened and warmed on the mixing mills. Instead of spreading it on with a knife as is done with Fabrikoid, we calender or roll it upon the fabric. The calender has four carefully ground steel rolls approximately 64 in. wide and 24 in. in diameter. The rolls are equipped with heating and cooling coils. The compound is fed into the calender between the upper two rolls. These sheet the rubber out upon the second roll, from which it passes on to the third roll. A sheet of compound is also placed between the second and third rolls to prevent calender skips. The fabric is passed

[1] Technical superintendent, E. I. du Pont de Nemours & Co., Fairfield, Conn.

into the calender between the two bottom rolls and the rubber film is transferred to the fabric.

A quick-drying varnish that dries free from tackiness is applied as the fabric leaves the calender. The coated fabric then passes over an automatic weighing-scale which flashes a signal when the material is over or under weight. This equipment is invaluable in controlling the weight of the finished material.

After the application of the coating the material is ready for embossing. This is accomplished by passing the material between a hard paper roll and a heated steel roll engraved with a suitable pattern. The rubber-coated fabric is then ready for the finishing operation. This consists in applying varnish to it as it is festooned in a large chamber for vulcanization.

Two-ply fabrics, such as are used on most automobiles, usually consist of a sheeting combined with a drill. These fabrics are combined by first impregnating each with rubber cement, which is forced into the interstices of the fabric by two steel rolls. These fabrics are then pressed together by passing them between a pair of rolls, and the resulting two-ply fabric is treated like single fabric, as already described.

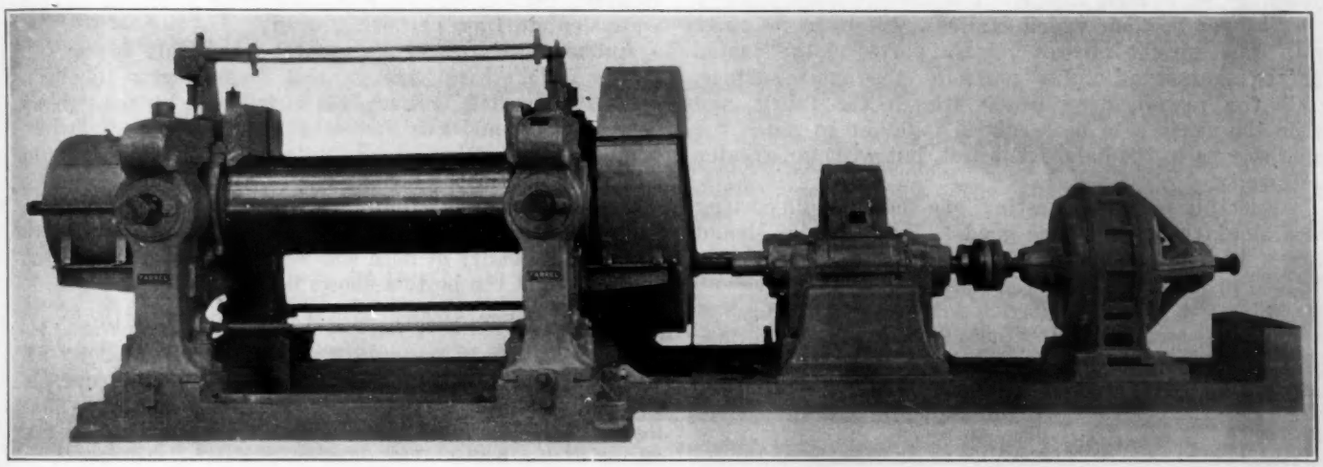

FIG. 1—MACHINE FOR MIXING COLORED RUBBER-COMPOUNDS AND CEMENTS

Two Polished-Steel Rolls Rotating at Different Speeds Draw the Compound Down between Them and Incorporate the Dyeing and Other Ingredients with the Rubber. After Mixing, the Compound Is Strained and Permitted To "Rest" for 24 Hr. So That the Rubber Will Set and the Compound Have Uniformity When Coated on the Fabric

TESTS APPLIED TO COATED FABRICS

Most large car-manufacturers in this Country use specifications to safeguard themselves in their purchases of all sorts of material. No industry or institution is more careful in this respect than the automobile industry. I believe it is general practice for the engineers and chemists in this field to supply these specifications to the purchasing agent and to see that the materials meet the specifications after he purchases them. This type of buying is unquestionably of distinct value to both the supplier and the consumer. It elevates the standard of manufacture, requires that the manufacturer shall become better acquainted with his own and competitive products, and assures the buyer that the supplier understands exactly what he wants and is supplying it to the best of his ability.

Many of the tests to be described herein cannot be made by the car manufacturer; others will perhaps seem superfluous, but it is hoped many of them will be found of value and applicable to work in the automobile plant. The tests were developed for the purpose of controlling accurately the quality of the goods made.

Three general types of test are applied to coated textiles. The first embraces those which may more properly be called observations, as they depend upon the senses, such as feeling, to determine pliability, and sight, to note color, grain, luster and the like. There are few accurate ways of making and recording such observations, which are largely a matter of personal opinion; and perhaps it is not desirable that they should be reduced to an exact qualitative basis.

The second class of tests consists of observations made in the laboratory by the use of machines which give definite quantitative data on the property being tested. These tests are the ones upon which the manufacturer and purchaser usually must depend to determine and record the quality of the goods.

A third class of tests comprises those which depend upon actual service for determination of the desirability of the goods. Such tests are very slow and in general are not very useful in connection with purchase specifications.

PHYSICAL TESTS ON COMPOUNDS

The most important test to which the rubber technologist resorts is the stress-strain test on the rubber compounds. Every well-controlled rubber factory determines the quality of the compound from its physical properties as shown by its tensile-strength, elasticity, and permanent set. These tests can be made on both new and aged stock, and give definite quantitative data. Our custom is to conduct these tests on naturally aged samples as well as on test pieces that have had their aging artificially accelerated. The tensile properties are determined in the familiar Scott machine. The purchaser is unable to make this test unless he can arrange to secure specimens of the raw compound from the producer, which I believe can be done easily. The Government often follows this practice.

SCRUB TEST USABLE BY THE CONSUMER

One of the oldest and most common tests applied to all types of coated fabric is termed the scrub test. As formerly carried out, a piece of the goods is grasped be-

tween the two hands so that the thumbs lie on top of the goods parallel to each other and perhaps ½ in. apart. The hands are then brought together and, with the piece of goods grasped firmly, it is scrubbed much as one might wash a fabric. The number of complete motions forward and back, counted as one, before the coating breaks, is called the "scrub" of the piece.

This test naturally gives very erratic results. The strength of the hands and arms of individuals who make this test varies widely. It is known also that the same individual varies a great deal in the performance of the test on different days. It is obviously impossible to accept for the scrub of a piece of goods a single attempt to determine quality of the coating in this way. This test, however, has been very useful and is still used to some extent. The modern successor of the hand-scrub test is the scrubbing-machine. This has two heads in which the sample is clamped. The heads are reciprocated in opposite directions by cranks and connecting-rods driven by an electric motor. The sample folds under a rider hinged to a bar which carries a weight at its outer end. The weight presses certain parts of the coated surface against adjoining parts of the same surface, while the reciprocating heads stretch the fabric and cause the surface to be scrubbed together in much the same way as in the hand-scrub test, but with far greater uniformity.

In selecting pieces for testing, one should avoid cutting them along the edge of the goods. Test samples should always be cut along the warp threads. The piece is clamped firmly in position with the jaws in mid-position. The weighted rider is then let down on the goods and the motor is started by the pull-chain switch. The machine is stopped as often as experience indicates is necessary and the piece is taken out and examined closely for a break in the coating. As the test progresses, the frequency of examination will increase for the purpose of accurately securing the end-point; that is, the point at which the first break in the coating occurs. It is best to make duplicate scrubs.

Scrubbing-machines are useful, not only for determining the initial quality of the goods, but in connection with other tests. For instance, the sunlight-exposure test and the heat-aging test are made much more valuable by applying the scrub test to the goods that have been exposed.

We find that, in addition to a control on compounds that have shown proper physical tests, the scrub test is a good indicator of resistance to abrasion, and we recommend this as a control test for the consumer, particularly if he does not test the compound.

Aging Tests Determine Ultimate Value

Efficient and rapid aging-tests are of utmost value in determining the ultimate value of any material. Materials that are entirely unsuited for the purpose they are to serve are purchased too often on their initial appearance and quality. The curves in Fig. 2 indicate graphically the fallacy of such judgment. Although Sample *B* shows a compound whose initial quality as measured by tensile-strength is superior, Sample *A* certainly is to be preferred. Accelerated aging-tests on rubber-coated fabrics are made in three distinct ways: (*a*) by aging in an oven at a temperature of 70 deg. cent. (158 deg. fahr.), (*b*) by exposure to ultra-violet light and (*c*) by the oxygen-bomb method.

For method (*a*) we are indebted to Dr. W. C. Geer, who pointed out that this test, when used properly, gives an approximate correspondence between accelerated and natural life-tests after 4 days in the oven, 1 day equaling 6 months' natural exposure. This test, however, does not take into consideration the effect of light. We have done some work on the use of the Fade-ometer for this factor and, although we have not yet drawn conclusions as to its relation to natural aging, we have reason to believe that it has a definite place in a well-equipped testing laboratory. We find that it is valuable in testing materials of the same class for deterioration of varnish finishes and for fading. The discrepancies encountered, however, make it imperative always to check these tests with actual exposure.

Test-method (*c*) is very new but has been found especially effective in determining the deterioration of rubber by oxidation. The test was worked out originally by J. M. Bierer and C. C. Davis, of the Boston Woven Hose Co. The aging is done by subjecting the rubber to oxygen at a pressure of 300 lb. per sq. in. at 60 deg. cent. (140 deg. fahr.). This test gives results which indicate that 10 hr. of this treatment produces effects equivalent to 1 yr. of normal aging.

Rubber-coated materials usually deteriorate in the following order: First, the varnish finish begins to check after storage and, second, this is followed by the rubber becoming less and less elastic until it finally cracks when bent sharply. With good material, the latter should not occur within the normal life of an automobile.

Two specimens of rubber deck-material that have been exposed for the same length of time are shown in Fig. 3. The initial quality of both was very nearly the same, but the sample at the bottom shows decided decomposition.

Fold Test Shows Resistance to Breaking

The fold test is made with a machine operated by an electric motor, which stretches the goods and folds it sharply under a 10-lb. weight 40 times per min. This test is continued until the coating shows a distinct break at one of the folds. The number of foldings required to cause such a break is taken as the end-point. Fold tests, like scrub tests, can be carried on for a definite period, after which the material is subjected to other tests to determine the effect of vigorous folding or creasing.

This test was designed primarily for testing automobile-top materials, and when so used it usually is preceded and followed by the hydrostatic test, for much the same reason that the aging test is accompanied by the scrub test.

Test for Permeability by Water

The hydrostatic test was devised for the purpose of determining the hydrostatic resistance of coated fabrics. The material is tested in duplicate or triplicate by clamping sample pieces face inward over flanges on horizontal pipes that are connected with a vertical pipe, into which water is fed at such a rate that the water-level rises 2 ft. per min. When water makes its first appearance on the back of the fabric, which is outside, the water is shut off and the height of the column is noted on a gage glass.

Any good top-material will withstand for a long time a hydrostatic pressure equivalent to 10 ft. of water without any leakage. If it resists this even momentarily when new, its hydrostatic resistance is satisfactory. After being subjected to the fold test for a reasonable number of times, say 300, it should withstand a pressure equivalent to 2 ft. of water.

Anchorage Test Shows Adhesion of Coating

Adhesion of the coating film to the fabric base is commonly spoken of as the anchorage of the material. This

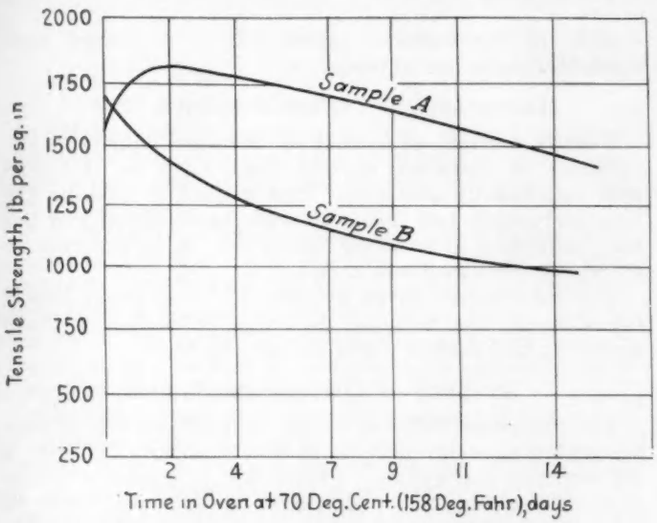

FIG. 2—AGING EFFECT ON TENSILE-STRENGTH OF RUBBER-COATED FABRIC

Initial Appearance and Strength of Coated Fabric Are Not Safe Guides to Its Quality. Sample *A* Shows Approximately 500 Lb. per Sq. In. More Tensile-Strength than Sample *B* After 4-Days Aging in an Oven at 158 Deg. Fahr., Although before the Aging Test Sample *B* Possessed the Greater Tensile-Strength

property is important and a satisfactory test for it is highly desirable. In the past the anchorage was judged by determining by hand how easily the film could be loosened and stripped from the fabric. Results of hand tests for anchorage depend entirely on the judgment of the individual making the test and, therefore, introduce the undesirable personal equation, as in the case of the hand scrub-test. Hence it is evident that a test which will yield consistent results, and that can be expressed numerically, is desirable.

After some preliminary experiments, suggested by the Bureau of Standards test of "frictioning" in rubber belting and the like, a procedure was developed that has been adopted as standard for determining the anchorage of the film. Application of this test to rubber-coated fabrics is as follows: By means of a spreader knife or spatula a piece of cotton drill measuring 2 x 8 in. is given two thin coats of rubber cement, compounded of 40 per cent smoked sheet, 4 per cent resin, 6 per cent shellac and 50 per cent benzol, and is permitted to dry at room temperature for approximately 5 min. After the varnish has been partially removed by buffing, a third coat of rubber is applied to a 2 x 8-in. piece of the material whose anchorage is to be determined and which has previously been cut to match the drill with the warp. The sample is then allowed to dry for a short time, after which the two pieces are pressed together evenly and firmly by means of a calender. Following this, the material is allowed to rest for 3 hr. The anchorage is then determined in the Scott or some other make of tensile-strength testing-machine.

The procedure is to separate the two fabrics at one end of the strip and pull them apart for a distance of about 2 in., being careful to have the film of the original material adhere to the coated sheeting. This can be done successfully if care is taken to start the separation properly. The 2-in. portions that have been pulled apart are narrowed to a width of 1 in. so that they will fit the clamps of the machine. They are then pulled apart, in the Scott machine, at a speed of 2 in. per min. It is necessary that the fabrics separate cleanly when being pulled apart. If there is a tendency for the fabric to ravel at the side of the test piece, this must be corrected by cutting the threads, as the raveling causes an appreciable error in the result. Results of the tests are reported as pounds of pull necessary to strip a test piece 2 in. wide. This procedure has yielded very satisfactory and consistent results.

TEST FOR STRENGTH OF COMBINING

To obtain accurate and reliable data on the strength of combining of double-texture material, both before and after aging by heat and weather, it has been found necessary to develop a method of testing under uniform conditions. The anchorage tests required only a little modification to give satisfactory results for strength of combining. The method of operation can be inferred readily from the description of the anchorage test.

RUBBER TESTED FOR SULPHUR BLOOMING

When rubber is vulcanized by means of sulphur, only a portion of the sulphur that is added combines with the rubber, and the remainder is held in the rubber while it is vulcanizing. After a time the free sulphur may crystallize out, and the rubber is then said to have "bloomed" or "sulphured up." The manufacturer usually knows the quantity of free sulphur the compound will hold without blooming, and he tests the coating for free sulphur periodically. The purchaser's most practical way of checking for blooming is merely to store a sample

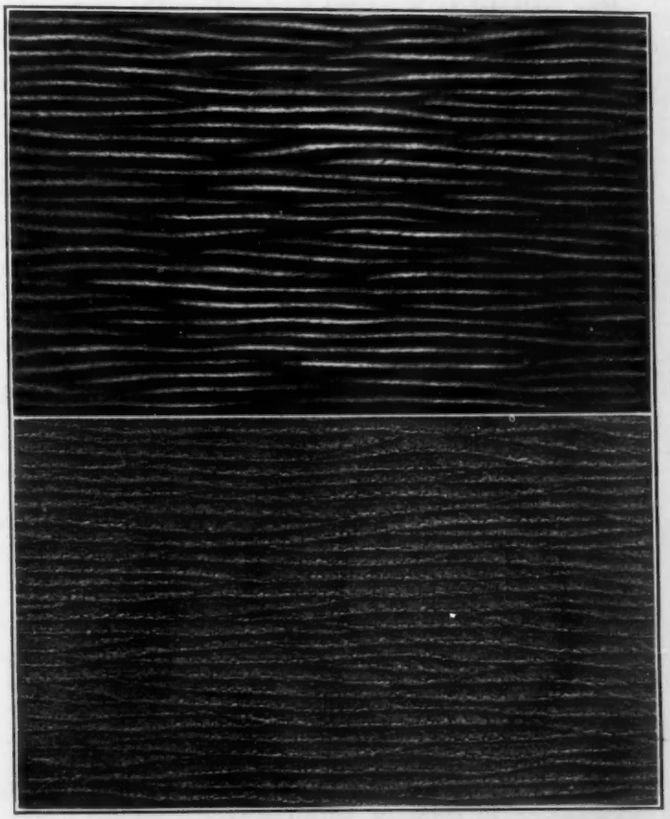

FIG. 3—RESULTS OF EXPOSURE OF TWO SAMPLES OF RUBBER-COATED FABRIC

Both Specimens of Deck-Material Were of Very Nearly the Same Initial Quality and Were Exposed for the Same Length of Time. Whereas the Sample at the Top Shows Little Effect of the Exposure, That at the Bottom Shows Decided Decomposition and Cracking of the Coating

in a cool dark place and observe it periodically for this defect.

Weather-Exposure Test Extends over 1 Year

Exposure tests, in general, may be regarded as accelerated service-tests, as the results obtained give, in a comparatively short time, an indication of the general wearing-qualities of the coated material. This test has been found of greatest value in testing automobile-top materials. The time of the exposure is usually 1 yr., because it is desirable to have the material subjected to the weather conditions of the four seasons. A 1-yr. exposure is regarded as equal to about 3 yr. of actual service.

A frame 4½ x 5 ft., having three equidistant cross-members, is made from 3 x 1-in. stock and supported by suitable uprights at an angle of 45 deg., facing south. The sample of material to be tested must be of sufficient size to cover the top of this frame and leave at least 3 yd. for the "retained sample." Observations and tests on the original material are made for the following properties:

Appearance	Smoothness
Luster	Pliability
Tensile-strength	Resistance to scrub
Hydrostatic resistance	Strength of combining cement

A fold test of 300 folds is also given the material and, after noting its appearance, a hydrostatic test on the folded portion is made.

The material to be tested is placed on the frame and drawn tightly over the edges before fastening, so that a pocket will not be formed that will collect water in a rain. At the end of each 3-months' exposure, a strip is cut from the material on the frame and the tests and observations just listed are repeated on both the exposed sample and a portion of the retained sample. At the end of 1 yr. of exposure, all the results are tabulated and conclusions are drawn from the data obtained.

It is important that the frames be so located that the material being tested will be exposed to rigorous conditions. It has been observed that exposure in a manufacturing city causes much more deterioration than is produced in clean country air. Owing to the varying conditions at different periods of the season, exposure tests on rubber or pyroxylin goods always are conducted in a way to obtain comparable results. When a manufacturer desires to determine the aging quality of a competitive material, he usually exposes it together with a sample of his nearest comparable quality. Similarly, when he makes a change in compound, his standard sample is exposed together with the new sample, so that comparable data are always available.

Test for Resistance to Edge-Cracking

The edge-cracking test is applied only to rubber-coated fabrics. It is a very important test on automobile-top fabrics, because it simulates the effect of tension, creasing, and deterioration due to weather exposure, on turned edges, one of the first places where a top shows wear. This test is performed by cutting a sample of the material 13 x 2¾ in. with the length parallel to the warp. The material is then suspended over a sharp edge, with the coated side out, in the form of a loop within which is placed a 2½-lb. weight. This sharp edge should be made of metal, preferably brass, and the bend of the goods over it should form an angle of 60 deg.

This test is comparative only, and its duration is dependent upon weather conditions as well as upon the quality of the material tested. It is continued until definite results are obtained.

Importance of Tensile-Strength Test

Tensile-strength of coated or uncoated fabrics is determined by machines designed especially for this purpose and readily available. The method of making the tensile-strength test has been well standardized and has been described in so many places that it is unnecessary to repeat the directions here.

The information given by this test is of great importance where the material is to be subjected to much stress, as in upholstery and automobile tops.

Analysis of Coating and Fabric

The procedure followed in the routine analysis of rubber-coated material consists in first stamping out with a die a sample 4 x 3.81 in. The weight in grams of a test piece of this size, when multiplied by 3, is equivalent to the weight of the material in ounces per square yard. First the film is removed with benzol or naphtha, then the fabric is dried and weighed, and the difference between this weight and the weight of the test piece is the weight of the coating. Weight of the coating is expressed in ounces per running yard and that of the fabric in yards per pound.

In the case of double-texture fabrics, the weighed sample, after the coating is removed, is treated with "paraffin white spirit"; that is, distillate at 130 to 220 deg. cent. (226 to 428 deg. fahr.) from motor gasoline. Then the two fabrics are separated. The cement is freed from the fabrics by scraping them with a spatula and extracting the remainder with more solvent.

Fabric-analysis tests are of great importance because two pieces of material may be very similar in total weight and appearance, yet different in cloth structure. The kind of dye used on fabrics is also important, especially on the type of material now used on sport cars. We recommend testing this material to make certain that it is in accordance with specifications. Our attention was called recently to an instance of substitution of sulphur-dyed material where Indanthrene dyes were specified. This made a difference of about 20 cents per yard in the cost of the finished material. The sulphur-dyed material, in the color furnished, was entirely unsatisfactory.

Two Ways of Using the Tests

Although we feel that the tests herein described clearly indicate the value of most coated textiles, it is not necessary to employ all of the tests in the case of any coated fabric for a specific purpose. The purchaser need specify and apply only those tests which indicate the qualities necessary for deck material for his individual uses. Some of the tests can be written into specifications; others are of greater use to the purchaser in deciding what makes or types of automobile topping are best; that is, they are broader tests than are required for specifications.

There is reason to believe that more careful examination of materials of the type under discussion will assure the purchaser of securing material well adapted to his needs and will enable the manufacturer to interpret the requirements of his customer more accurately. It seems likely that there will be greater satisfaction on the part of all concerned if they have a definite appreciation of the characteristics of topping materials. The series of tests described will contribute a great deal toward this understanding.

THE DISCUSSION

QUESTION:—What advantage has pyroxylin-coated fabric over rubber-coated fabric in withstanding continued strain and holding its original luster when used for top material?

E. H. NOLLAU[2]:—Whether one is superior to the other depends largely upon how good one or both of the materials may be. In the past there has been considerable question about the retention of luster on rubber, but the company I represent has developed a varnish that is superior to any varnish I have ever seen and is superior to many pyroxylin materials.

QUESTION:—Does your company recommend one or the other coated fabric for top material?

MR. NOLLAU:—It is a matter of opinion. Both rubber and pyroxylin coatings give excellent service.

QUESTION:—What is the relative durability of the rubberized and the pyroxylin-coated materials under the scrub test?

M. N. NICKOWITZ:—The scrub test should not be used to compare two materials of different type, because it does not affect the two materials in the same way. I should use the scrub test only in comparing different rubber-coated goods. Rubber gives a high scrub-test. On the other hand, pyroxylin certainly is more suited for some uses than rubber. The scrub test is not a fair test for comparing the two materials.

CHAIRMAN W. T. FISHLEIGH[3]:—If you were testing two materials for top use, what test would you use?

MR. NICKOWITZ:—The service test; outdoor exposure in extreme weather.

QUESTION:—Has any test been developed that can replace the weather test by exposure on the roof?

MR. NOLLAU:—We are working on one that is highly desirable.

QUESTION:—Does roller embossing have a tendency to weaken the material, and if so, why?

MR. NICKOWITZ:—Rollers do not affect the rubberized material if the pattern is properly designed.

MR. NOLLAU:—So far as pyroxylin is concerned, ordinary rollers do not weaken the coating. Certain grains in which the valleys are extremely deep produce the same result that would occur in the roller or plate test.

EFFECTS OF UNDER AND OVER-CURING

QUESTION:—Does blooming have any effect on the aging qualities of rubber, and how does it affect the mechanical properties?

MR. NICKOWITZ:—That depends largely upon the type of material. The objection to blooming is its effect on appearance. It is very undesirable to have blooming appear on rubber deck-material. Ordinarily, a bloomed material will age better than a material made of the same compound that does not bloom. That is likely to be due to over-curing of the latter.

QUESTION:—What is the effect of over-cure or under-cure of the material, and how can over-cure be determined by inspection?

MR. NICKOWITZ:—If under-cured the material is likely to become soft or soggy, and if over-cured it becomes brittle and cracks. Whether over-cure can be discovered by inspection depends upon how much the rubber is over-cured. The manufacturer must maintain perfect control of his vulcanizers so that neither of these defects will occur. If they do occur, it probably will be revealed in the aging tests. If the rubber is over-cured badly it will crack wide open; if under-cured, it will be soluble in ordinary rubber solvents.

QUESTION:—How do rubber-coated and pyroxylin-coated materials compare with leather as regards price and general life? If they are superior, why are they referred to as leather substitutes?

MR. NICKOWITZ:—The rubber-coated fabrics are not usually referred to as leather substitutes. On price, I believe the rubberized fabric is the cheapest of the three, weight for weight and applied for the same use. Any coated textile that will give satisfactory service is much more suitable for a deck material than leather, from a manufacturing standpoint, on account of the ease with which it can be handled. There is a large variation in hides and they come in cumbersome shape. So far as a deck material is concerned, leather is not worth the effort to apply it, as leather substitutes, such as pyroxylin-coated and rubber-coated fabrics, give satisfactory service.

TEST BY ULTRA-VIOLET LIGHT INSUFFICIENT

QUESTION:—Would the quartz lamp, as used by paint manufacturers, give a test on rubber and fabric?

MR. NOLLAU:—We have been working on such a test for a number of years. The difficulty is to interpret the results in terms of actual service. That has been proved a number of times when we subjected a sample to ultra-violet light and obtained extremely good aging, but when that material was exposed outside we got just the reverse results on luster, cracking, and the like. It seems that what is necessary is to incorporate in the test the other conditions that affect materials on exposure in service, such as alternating heat and cold. With these ideas in mind, we are trying to develop an accelerated test that will give us the results of actual exposure.

QUESTION:—Why is it not possible to produce rubber decking in colors, when raincoats and bathing shoes are made of colored rubber?

MR. NICKOWITZ:—We have been working for more than a year on a colored-rubber decking-material. The chief reason for not coming out with a rubber deck-material in colors is the difficulty in producing something that will withstand weathering conditions. It is not difficult to make a rubber compound that will withstand weathering, but it is difficult to obtain a good finish for it. Raincoats are subjected to much less sunlight aging than is an automobile top. Finishes on most raincoats are not very resistent to sunlight. If that sort of finish would be satisfactory, we could easily produce colored deck-material.

QUESTION:—What effect has engine and car vibration on top materials?

MR. NOLLAU:—I suppose the so-called torsion in the car is meant. If enough of this sort of action is exerted, the bond between the two films of the material will be released in time. We never have made any actual tests on this because we never have had occasion to determine that action.

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[3] M.S.A.E.—Engineer, Ford Motor Co., Detroit.

Structure of the Atom

By E. F. Barker[1]

Semi-Annual Meeting Paper *Illustrated with* Photographs and Chart

ALL matter is composed of atoms; hence atoms are the most important things in the universe, and we should know about them.

The old theory was that the atom was indivisible, indestructible, and unchangeable. The theory of conservation of matter and of energy held that neither can be increased nor diminished although they can be changed in form.

Scientists now hold that the atom consists solely of electric energy and that matter and energy are interchangeable. In short, all elements, whether gaseous or solid, are merely electric energy.

The atom is so infinitesimal that we never can hope to see it through the most powerful microscope, but Dr. Barker gives a graphic description of the structure of the atom, beginning with the simplest and building up by increases of electric charges of the nucleus and the addition of negative electrons until the structure becomes almost too complicated to illustrate clearly with a model. The structure bears a striking resemblance to the planetary system of the universe.

In a fascinating way he clarifies the reasons why some elements are gases and some are solids, why some are inert and others active chemically; explains the open structure of the atoms of even a metal so dense as copper and why it is possible to "see" through them with ultraviolet rays; tells the significance of the valence of active elements, how one electron of very active atoms can be removed easily to form positive and negative ions, and the practical application of this principle to the photoelectric cell; and makes understandable the periodic volumetric change in elements from gases to solids with successive increases of nuclear charge and additions of electrons.

THE science which deals with the physical and chemical properties of matter has assumed an extraordinarily important place in our modern civilization. In the light of this fact, it is very interesting to observe how recent has been the development of this science and how nearly empirical has been its basis until the last few years.

There was much confusion 150 years ago about what constitutes a chemical element, and only a few of the elements with which we are familiar had been recognized. Little distinction was made between pure substances and compounds, as between pure metals and alloys, for instance. During the 19th century, chemistry passed through what might be called the descriptive phase, beginning with the isolation and identification of the various elements; first the metals, then the earths, later the gases, and gradually the rarer elements.

This process is not yet complete, although nearly so. We are now acquainted with 89 elements, and anticipate the discovery of three more. The architecture of these last three elements is so well in mind, however, that not much new information will be gained from their discovery, as we can already predict their properties with great precision; in fact, this information affords the only hope for discovering them, as it enables us to look for them in exactly the right places. The most recent element added to the list of known elements, and the only one to be discovered by an American, was added within the last few months at the University of Illinois and has been given the name illium in honor of the State University. This is No. 65 in the list of elements.

Matter and Energy Are Interchangeable

If we should indulge in the game of creation for a few minutes it might be possible to controvert the idea of the indestructibility of matter and the impossibility of the creation of matter. The chemist has taught us conservation of matter and to write an equation the only basis for which is that everything present in the beginning is present at the end. Physicists for a long time have taught the idea of the conservation of energy. We are beginning now to understand that matter and energy are the same, and we have rather the idea of conservation of matter-energy. We no longer believe that matter cannot go out of existence and appear again, but whenever it does so disappear energy is produced, and if energy goes out of existence matter appears. These two are, in fact, interchangeable.

The conditions under which this interchange occurs are beyond our control. Experiments of this sort cannot be performed in the laboratory. We may, however, create in fancy a few of the simpler elements. The material with which we begin consists of electric charges; negative electrons, familiar to all since the advent of the amplifying radio-tube, and positive protons, which built up the nuclei of our elements. Such particles are extremely minute; there is no hope that a microscope ever will reveal them to us. Our only method of procedure will be either to become, in imagination, exceedingly small ourselves or to permit the world around us to grow.

Infinitesimal Size of the Atom

Assume that a ball 2 in. in diameter grows to 1000 miles in diameter. Now its texture begins to appear, and upon close examination we may perceive the atoms of this ball. Expand it to 8000 miles, the size of our earth, and even this is not enough. Expand it to 200,000 miles in diameter and the atoms become about 1 ft. across. Even with this magnification the electrons which form a considerable part of each system, the external portion, appear only about 0.01 in. across, and the nuclei are approximately the same size.

Let us change the simile now from a ball to a block of copper. We may think of the atoms of copper as structural units each consisting of 30 minute particles, one nucleus surrounded by 29 electrons. The size of each particle is about 0.01 in., making it barely visible, while the whole group is about 1 ft. in diameter. The density of material of this sort is strangely apparent rather than

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real; you can thrust your hand through it without much danger of disturbing its parts. It would seem, then, as if we should be able to see through this copper, and we can with light of proper wave length. If we reduce the wave length as we have reduced our own relative size in viewing this object, the wave length is of the right dimension to penetrate the atoms. For this reason alone X-radiations penetrate matter even as dense as copper and the heavier elements.

Elements Composed of Electrical Charges

The particles of which elements are built are nothing but electric charges, positive and negative. Their properties are due entirely to the electric and magnetic fields associated with them. They may be influenced by neighboring electric and magnetic fields but by nothing else. If the energy of their fields be dissipated by radiation, they go out of existence completely.

As an atom of copper is rather complicated, let us think of the very simplest atom, one of hydrogen. Imagine a small positive particle with a little red ball, representing the negative electron, executing an orbital motion upon a wire ring encircling the nucleus. This single electron revolves about the central sun at exceedingly high speed, millions and millions of circuits per second, and the diameter of its orbit is of about the order of 0.00000001 in.

An atom of this sort is exceedingly active because it has very intense electric and magnetic fields; hence it reacts with great violence when it comes into contact with any other electric and magnetic fields, that is, with any other atoms. This explains the interesting behavior of the atomic hydrogen flame described at Schenectady, N. Y., a few months ago by Langmuir, who was able to do welding with this flame, obtaining with very little difficulty temperatures that are higher than can be produced in any other simple way. Mere contact of the hydrogen gas with the surface of a metal generates at once an exceedingly high temperature.

Increased Nuclear Charge Adds Electrons

If the charge upon the positive nucleus of the hydrogen atom be doubled, it attracts two electrons and binds them closer to itself, so that their orbits are smaller. The result is an atom of helium. I represent the orbits diagrammatically as a pair of circles in two intersecting planes, with the positive nucleus at the center. As a matter of fact, the orbits probably are not fixed in space, but the whole system continually twists and turns, due to the mutual repulsions of the two negative charges. Each electron reacts upon the other so that they actually move around in a very complicated way. Helium belongs to one of the latest groups of elements discovered, the inert gases. It has very little tendency to form chemi-

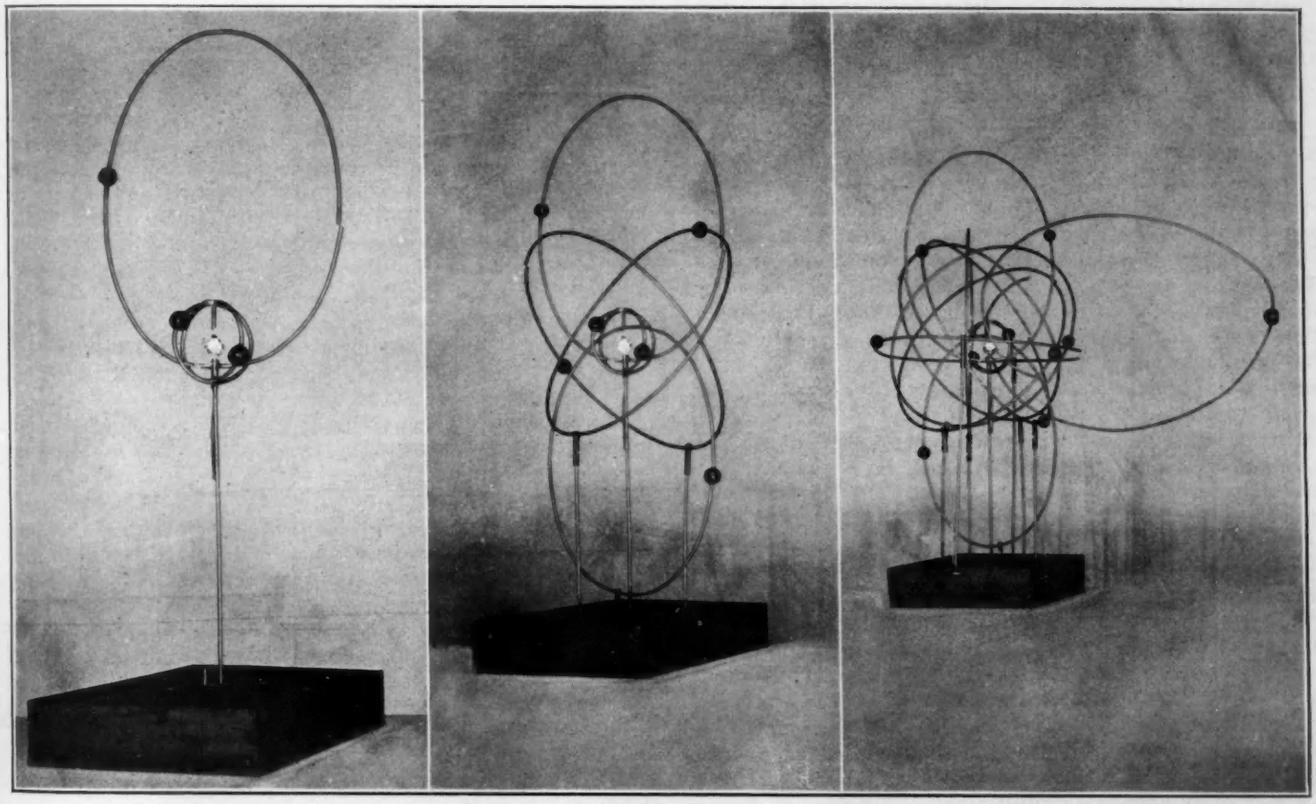

Fig. 1—Model Used To Demonstrate the Structure of Simple and More Complex Atoms

At the Center of Each Is a White Ball, Representing a Positive Nuclear Charge of Energy. Surrounding This Are Red Balls Representing Electrons, or Negative Charges. The Electrons Travel Circular or Elliptical Orbits Represented by the Wire Loops, Some Close to and Others Relatively Remote from the Nucleus. As the Positive Charge of the Nucleus Is Increased, Electrons Are Added and the Planetary System Shrinks. A Single Electron Following a Very Eccentric Orbit, as at the Left and Right, Gives the Element Formed by the Atoms a Valence of 1 and Renders the Element Very Active Chemically. The Structure at the Left Represents an Atom of Lithium, Having a Nuclear Charge of 3, an Inner Shell of Two Electrons, and a Single Valence Electron in a Large Orbit. A Carbon Atom, Represented in the Central View, Has a Nuclear Charge of 6, and, in Addition to the Two Electrons Forming the Inner Shell, Has Four Valence Electrons, of which Two Have Elliptical and Two Have Circular Orbits. The Sodium Atom, Represented at the Right, Has a Nuclear Charge of 11, an Inner Shell of Two and a Completely Satisfied Outer Shell of Eight Electrons; and One Valence Electron in a Widely Eccentric Orbit. The Change in Scale of the Photographs Is an Attempt To Show the Approximate Relative Dimension. The Sodium Atom Is Very Little Larger than the Lithium Atom

cal combinations and is absolutely non-inflammable, therefore has become of importance particularly in connection with our airship program.

Why Some Elements Are Chemically Active

If the charge upon the nucleus is increased to three units, and the size of this helium atom consequently decreased, it might be represented by the small model at the left in Fig. 1. This atom, with three charges upon its central nucleus, and two electrons, is not electrically satisfied. A third electron must be added to satisfy it, and investigation shows that this time the added electron travels an elliptical orbit instead of a circular one, with the major axis of the ellipse about twice as great as the minor axis. This ellipse penetrates within the shell of the inner structure, somewhat as the model indicates. We thus have an atom of lithium, an element that is monovalent and extremely active chemically. It forms compounds with other monovalent substances, a behavior explained by the fact that it has one electron in a large orbit, which electron may be rather readily removed.

Further increase of the nuclear charge by one unit requires another electron to neutralize it, and we arrive at beryllium, with the atomic number 4. The fourth electron is added in an elliptical orbit of approximately the same shape as the third orbit. We must imagine, as we proceed, that the scale of the whole structure is shrinking step by step, as the charge upon the central portion increases, due to the greater electrostatic attraction.

Compact Atomic Structure of Crystalline Elements

With another increase in the charge upon the nucleus by one unit, to five in all, another electron is attracted, and investigation shows that this fifth electron is added in a circular orbit, the diameter of which is just about equal to the major axes of the two previous ellipses. The space configuration of these orbits is somewhat doubtful. The picture presented by the model may not be correct in all details, but it represents fairly well the information collected from a study of the inner constitution of the various atoms. The resulting element, boron, forms extremely rigid crystals and possesses, on that account, great hardness, which property may be explained in terms of the atomic structure here represented.

Suppose that a sixth positive charge is added to the nucleus and another electron therefore attracted by it, thus forming the element carbon, with six electrons in each atom, two in the innermost shell lying very close to the nucleus, and four in what may be called the outer shell, lying relatively far away. Two of these outer four have elliptical orbits and two have circular orbits, as in the center view in Fig. 1. Carbon has a valence of 4, which may be attributed to the presence of the four electrons on the outside of the structure of the atom. As we shall see later, it has a very considerable tendency to complete the outer shell by the addition of four more electrons. Carbon atoms, therefore, combine with one another in an extremely rigid manner, forming the crystal whose hardness is the greatest of any that we know; i.e., the diamond. The form of this crystal may also be correlated satisfactorily with the structure that we have before us.

Why Valence of Nitrogen Is 3

Passing to the next element, increasing the charge upon the nucleus to seven instead of six and adding one more electron, we must still imagine that the scale of the whole system is diminishing. This seventh electron, again having a circular orbit, may be represented by a seventh wire loop, and the result is an atom of nitrogen. Its valence is 3, not because it possesses five electrons which may be removed, but rather because it has a tendency to complete the outer shell surrounding the nucleus by the addition of three more electrons.

Once more increasing the nuclear charge by one unit, an eighth electron is added, again in a circular orbit. We now have the element oxygen. The structure of the atom is beginning to assume a certain spherical symmetry, but there are points of attack from two sides where one might imagine an electron could be drawn in toward the nucleus; in other words, there are regions where the nucleus is not well screened by outer electrons. This means that the oxygen apparently has two points of attachment, or a valence of 2, and readily attracts to itself two atoms which have a single valence electron, as, for instance, atoms of hydrogen. This structure, if we imagine two atoms of hydrogen attached in such a way that the openings were fairly well covered, would form for us the molecule water, H_2O.

It must be emphasized again that, although the structure as we have imagined it built is static, this is because the model is too simple; the positions of the orbits are undoubtedly in a continual state of change due to the influence of one electron upon another. Thus the motion is much more complicated than that of our solar system, in which each of the planets is attracted toward the sun and each attracts the others, but with a force which is relatively insignificant.

Elements That Form Negative Ions

Another accession by one unit to the charge upon the nucleus produces the element fluorine, atomic number 9, with two electrons in the innermost shell and seven in the outer shell. This is an element in which the whole inner system is fairly well hidden except from a single direction. On one side the nucleus is still open to attack, and this element exhibits a single valence, an electronegative valence, as we say, or an affinity for electrons. In solution it forms negative instead of positive ions by borrowing from some indulgent neighbor an extra electron to complete its structure.

If we permit the nuclear charge to be increased by still another unit and balanced by one more electron, we observe at last a structure with a very marked spherical symmetry. It has a nucleus with 10 positive charges surrounded by 10 electrons so distributed that together they act as a guard around the central attracting charge; or, putting it differently, so that the electrostatic field associated with the whole system is fairly well neutralized for all points lying at any appreciable distance from it. The result is neon, an element which affects and is affected by its neighbors very slightly. It has, as we say, a valence of zero, and belongs to the class of elements we call the inert gases. It forms no chemical combinations. Each molecule consists of a single atom and does not combine even with other molecules of its own kind. It has an extremely low boiling-point, which shows that there is very little attraction between the molecules; in fact, this gas must be reduced to a temperature of approximately —230 deg. cent. (—382 deg. fahr.) before it can be liquefied under any pressure.

With a positive nuclear charge of 11 units, the whole system having now shrunk so that it is not much larger than the central portions with which we started, the 11 positive charges upon the nucleus, with 10 electrons lying outside, constitute again a monovalent positive ion,

that of sodium. And when one more electron is added it must be placed in a very eccentric orbit which penetrates deeply into the atom and may be conceived as somewhat like the large ellipse at the extreme right in Fig. 1.

We now have an atom with characteristics closely resembling those of lithium, which we encountered as atomic number 3. The lithium atom consisted of the inner shell, having two electrons, and one electron in a larger elliptical orbit. Sodium consists of an inner shell which again corresponds to an inert gas, neon, with 10 electrons, plus one electron in a large elliptical orbit. This last electron is very easily removed, which makes sodium an extremely active atom chemically, as was lithium. The removal of this single electron leaves a structure which is remarkably rigid; thus the valence of this element is 1, and 1 only.

Properties of Elements Repeat Themselves

Although sodium is extremely active, it is, in the ionic form, very inactive. If some sodium chloride is dropped into a glass of water, solution follows immediately, forming positive ions of sodium and negative ions of chlorine. The positive ions of sodium float in the water indefinitely and create no excitement. This reveals that the chemical behavior of the sodium ion is entirely different from the chemical behavior of the sodium atom. In fact, the sodium ion, except for a residual electric charge, is quite of the same nature as the inert gas. It has very slight tendency to form combinations, except with other ions which happen to be charged negatively. It is this extra-extended electron orbit which results in the great activity of sodium atoms.

We might proceed along this line all the way through the periodic table. The structure, however, would become more and more complex, and there would be very little new in principle to add. If we arrange all the elements that we know in the order of their increasing nuclear charge, which is almost the same as the order of their increasing atomic weights, certain properties repeat themselves from time to time. This results in what is called the periodic table of the elements, and the repetition of these properties may be at once correlated with repetitions of much the same general design on the outside of the atom. In fact, it becomes obvious at once that the whole behavior of the atom is a function of the electrons which lie at the very outside, those lying deep within the shell reacting not at all to their neighbors, being entirely protected by the electrons that lie outside.

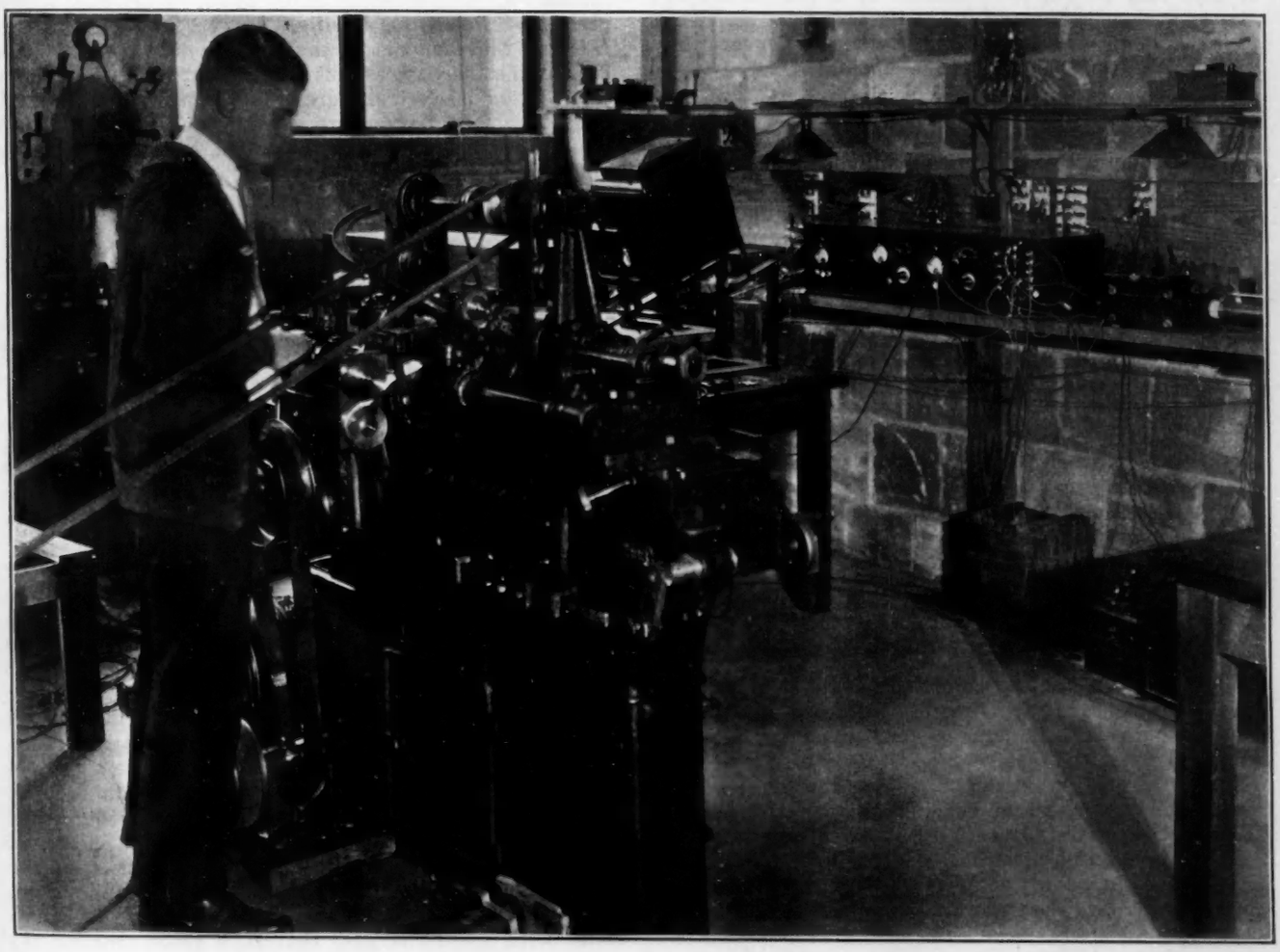

FIG. 2—EXPERIMENTAL FORM OF "ELECTRIC EYE" MACHINE FOR INSPECTING BEARING ROLLERS

An Intense Beam of Electric Light from the Lantern Mounted on the Machine Is Projected upon the Surface of the Rollers, Which Pass Down the Curved Trough at the Left and Are Rotated Rapidly in the Beam on a Spindle. Any Minute Defect in the Finish of the Surface of a Roller Decreases the Intensity of the Light Reflected to the Cell and Causes It To Operate an Electric Circuit and Open a Trap That Discards the Roller. In Front of the Machine Stands Prof. Floyd A. Firestone, of the University of Michigan, Who Directed Its Development. A Similar Method Is Used in Michigan for Inspecting or Cleaning White Beans

Changes occur in the inner submerged levels only as a result of the most intense forms of excitation, and reveal themselves to us in the form of penetrating X-radiation.

Electrons Easy to Remove from Atoms

Let us consider for a moment the possibility of removing electrons from atoms instead of building up the atoms. This process is very simple and can be performed in a variety of ways. If we merely heat the material to a high enough temperature so that the thermal agitation is sufficiently violent, atoms upon collision with one another will knock off those electrons which are easily removed. Thus we have the emission of electrons by thermal action, as obtained in a vacuum tube from the hot filament. A large number of electrons are immediately available from a filament raised to a sufficiently high temperature.

We may, if we wish, bombard such an atom with high-speed projectiles and thus remove the outer electrons; or indeed, if we have a sufficiently large quantity of energy in the projectile, we may remove some of the inner electrons. The projectiles may be other electrons available from a heated filament and accelerated by a considerable voltage so that they are given high speed, or they may be particles emitted by a radioactive substance, such as radium or one of its near relatives. These particles, emitted spontaneously, possess a very high velocity and thus a considerable amount of energy.

Practical Applications of Ionization Principles

We may ionize the atom, thus removing electrons, by a still simpler process. If we illuminate it with light of the proper frequency, electrons are carried off spontaneously with the absorption of the light. In fact, if the atom absorbs light at all, it does so by transmitting to the electrons kinetic energy, which, under the proper circumstances, means that electrons will be fired off from it. All substances exhibit this property when subjected to ultraviolet radiation. We call it the photoelectric effect. The photographic plate is an example of photoelectric sensitivity, as is also the retina of the eye. An element which is sensitive to light in this way may be used to build a "mechanical eye"; and if light be focused upon this eye, an electrical response is immediately evident, due to the emission of electrons from the material. If for any reason this light be interrupted, the electrical response stops at once. The speed of this reaction is enormous. Measurements have indicated that it is certainly more rapid than 0.000001 sec.

It is only within a comparatively short time that we have been able to measure intervals so short as this. I noticed recently that a photoelectric cell was set up on one side of a highway to record the number of automobiles that passed. Every time the light was interrupted by a passing vehicle the current ceased and a record was traced. Within the last year or two we have developed at the University of Michigan an instrument based on this principle for testing bearing rollers. It has been set up at the Canton plant of the Timken Roller Bearing Co. This inspection apparatus, shown in Fig. 2, focuses a beam of light upon the roller through a small microscope. The roller rotates rapidly in a little lathe and drops out. If the beam of light as it travels across the surface of the roller has been interrupted by a mark so fine that it is barely visible, the instrument reacts to the change in light intensity and opens a port, discarding the faulty piece. If no interruption has occurred the roller drops down the other side.

An enterprising firm in Michigan has arranged the same device for testing white beans. It opens the port whenever a stone or a brown bean comes down, and permits the white ones to pass. A process of this sort certainly has some great possibilities from the commercial point of view.

Characteristics of the More Complicated Elements

I shall now discuss briefly several of the more complicated elements and emphasize in particular a few of the things of special interest. Those elements in the atomic periodic table which have a single valence electron, and which therefore have a marked similarity in structure, are hydrogen, lithium, sodium, potassium, rubidium and caesium. These are the ones from which electrons are most easily removed. They have the lowest ionization-potential. Of all the known elements caesium has the lowest ionization-potential, and from it electrons are more easily obtained than from any other source. For this reason caesium has become particularly important of late as a material for coating the filaments in a vacuum tube, because if caesium forms the active surface the filament can be operated at a very low temperature and still a copious supply of electrons will be obtained. Photoelectric cells on the market are often coated with potassium, an easily available material which gives up its electrons readily.

Of all the elements in the periodic table, helium, the first of the inert gases, has the highest ionization-potential. From it electrons are removed with the greatest difficulty. All of the inert gases, which lie in the zero column of the table, as it is called, possess very high ionization-potentials.

In the part of the table including chlorine, fluorine, bromine and iodine lie those elements with a high electron-affinity; those in which the outer shell has almost reached the stage of the inert gas and needs but a single electron as a complement to make its symmetry complete. They are monovalent, therefore, but adopt an extra electron instead of losing it, and thus form negative ions instead of positive ions.

Periodic Change in Volume of Atoms

Fig. 3 illustrates the periodic behavior of the atoms, in particular with respect to volume. Atomic volumes are plotted vertically and a few elements are arranged horizontally. Note that the volumes rise and fall with obvious periodicity. At each peak lies one of those elements with the single electron in the outer shell. They are the ones which occupy the greatest volume. As the nuclear charge increases and more electrons are added. the structure shrinks. When a new shell is formed, the atomic volume rises again suddenly, forming the next peak.

Virtually all of the physical properties of matter can be plotted in a similar way, and the curves are much alike. The maxima do not always occur at the same elements, since they are determined by various factors. Boiling points, for instance, show maxima at the center of the table and minima for the marginal elements. This is because boiling points depend, not only upon the character of the electric field associated with the atom, but also upon atomic volume. Thus, if we have two atoms with given charges; that is, a given tendency to attract each other, the intensity of their reaction and the energy required to separate them again depends upon how close they may approach one another. The closer together two electric charges are brought, the greater is the amount of work required to separate them. Thus those elements with high boiling-points are in the lower

portions of this volume curve. They are iron, carbon, silicon, palladium and platinum.

Electron Groups for Inert Gases

Characteristic electron-groups for those inert gases which mark the end of each period in the table are given in Table 1. The letters at the top are a convenient means of designating the shells of the atoms. The inner one is commonly called the *K* shell; the second, which we have completed in the model, is called the *L* shell; the one just beginning with the single valence electron of sodium is the *M* shell, and so on. The numbers opposite the word "Orbits" indicate the shell to which each orbit belongs, while the subscripts reveal the eccentricities of the orbits. Thus, the minor axis is about one-third of the major axis for a 3_1 orbit and about two-thirds of the major axis for a 3_2 orbit, while the 3_3 orbit is circular.

In each of these inert gases the outer shell consists of eight electrons, two in very eccentric elliptical orbits, and six in less eccentric orbits. The latter are circular only in the case of neon.

Queer Metal and Rare-Earth Groups

In studying the periodic table one must sometimes have been curious about those peculiar groups which lie at the extreme end; iron-cobalt-nickel, ruthenium-rhodium-palladium, and osmium-iridium-platinum, as well as the family of 14 elements commonly called the rare

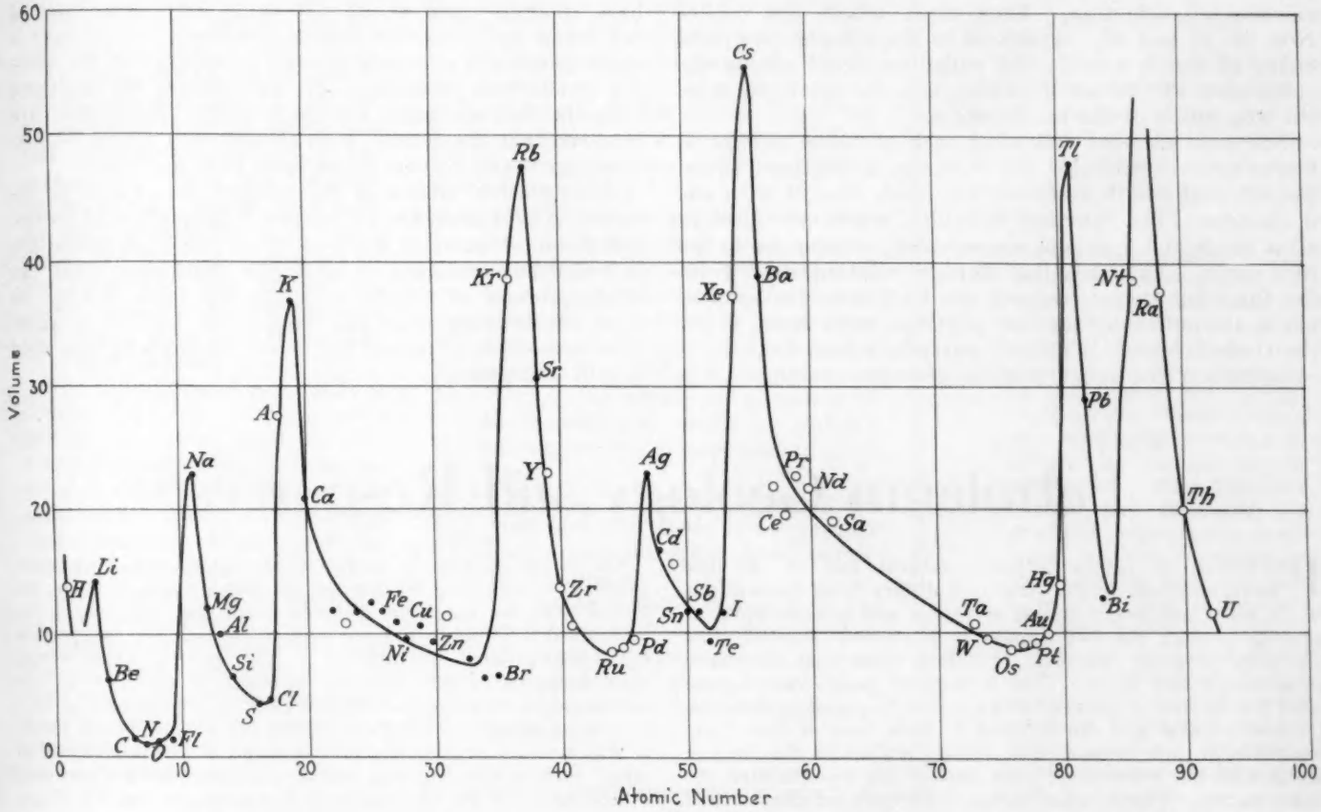

Fig. 3—Periodic Behavior of the Atoms, in Particular with Respect to Volume

Atomic Volumes Are Plotted Vertically and the Elements Given Are Arranged Horizontally in the Order of Their Atomic Numbers. The Volumes of Crystals, Represented by Solid Dots, Are from Data by Bragg, and Those for Gases, Represented by Circles, Are from Data by Meyer. At Each Peak Lies One of Those Elements Having a Single Electron in the Outer Shell and Which Occupy the Greater Volumes. As the Nuclear Charge Increases and More Electrons Are Added, the Structure Shrinks. When a New Shell Is Formed, the Atomic Volume Rises Again, Forming the Next Peak. The Symbols Designate the Following Elements:

Symbol Element	Atomic Number	Atomic Weight	Symbol Element	Atomic Number	Atomic Weight	Symbol Element	Atomic Number	Atomic Weight
H=Hydrogen	1	1.00	Cu=Copper	29	63.57	Cs=Caesium	55	132.81
Li=Lithium	3	6.98	Zn=Zinc	30	65.37	Ba=Barium	56	137.37
Be=Beryllium	4	9.10	Br=Bromine	35	79.92	Pr=Praseodymium	59	140.60
C=Carbon	6	12.00	Kr=Krypton	36	82.90	Nd=Neodymium	60	144.30
N=Nitrogen	7	14.01	Rb=Rubidium	37	85.45	Sa=Samarium	62	150.40
O=Oxygen	8	16.00	Sr=Strontium	38	87.62	Ta=Tantalum	73	181.00
Fl=Fluorine	9	19.01	Y=Yitrium	39	89.00	W=Tungsten	74	184.00
Na=Sodium	11	23.00	Zr=Zirconium	40	90.60	Os=Osmium	76	190.90
Mg=Magnesium	12	24.32	Ru=Ruthenium	44	101.70	Pt=Platinum	78	195.20
Al=Aluminum	13	27.01	Pd=Palladium	46	106.70	Au=Gold	79	197.20
Si=Silicon	14	28.03	Ag=Silver	47	107.88	Hg=Mercury	80	200.00
S=Sulphur	16	32.07	Cd=Cadmium	48	112.40	Tl=Thalium	81	204.00
Cl=Chlorine	17	35.46	Sn=Tin	50	119.00	Pb=Lead	82	207.10
A=Argon	18	39.90	Sb=Antimony	51	120.20	Bi=Bismuth	83	208.00
K=Potassium	19	39.10	Te=Tellurium	52	127.50	Nt=Nitron	86	222.40
Ca=Calcium	20	40.09	I=Iodine	53	126.92	Ra=Radium	88	226.40
Fe=Iron	26	55.85	Xe=Xenon	54	130.20	Th=Thorium	90	232.42
Ni=Nickel	28	58.68				U=Uranium	92	238.50

TABLE 1—CLASSIFICATION OF ELECTRONS IN INERT GASES

Atomic Number		Shells	*K*	*L*		*M*			*N*				*O*			*P*	
		Orbits	1	2_1	2_2	3_1	3_2	3_3	4_1	4_2	4_3	4_4	5_1	5_2	5_3	6_1	6_2
2	Helium		2														
10	Neon		2	2	6												
18	Argon		2	2	6	2	6										
36	Krypton		2	2	6	2	6	10	2	6							
54	Xenon		2	2	6	2	6	10	2	6	10		2	6			
86	Nitron		2	2	6	2	6	10	2	6	10	14	2	6	10	2	6

earths. The chemistry of these latter elements is exceedingly difficult, as all have very nearly the same chemical behavior and are almost impossible to separate. Many of the properties of these various groups can be explained in terms of structural relations indicated by the electron classification. Thus, iron, cobalt and nickel, Nos. 26, 27 and 28, correspond to the completion of the quota of ten 3_2 orbits; the palladium triad marks the completion of the ten 4_3 orbits, and the platinum triad the completion of the ten 5_3 orbits.

The next element following each of these groups is monovalent: copper, No. 29, with one 4_1 electron; silver, No. 47, with one 5_1 electron; and gold, No. 79 with one 6_1 electron. The fourteen 4_4 orbits, which are filled in after the 5_1 and 5_2 groups are complete, correspond to the rare earths. Their peculiar chemical relations arise from the fact that these electrons are built into the system, not at the outer surface, but relatively deep down, below the *O* shell, which is already partially completed. As a consequence, the outer portion remains practically the same over a considerable region of the periodic table; hence we have a number of elements of which the chemical properties are nearly identical.

In this brief resume of atomic physics I am conscious that the most interesting phase of the subject has not been touched upon at all. It deals with experimental facts and not with descriptive assertions. You have a right to ask for adequate reasons in support of the various conclusions presented. My only excuse for omitting them is that so many and such varied researches are involved that the details, even though they might be fascinating, would require much more time and space.

Among other phases of the subject that would be interesting to discuss are the magnetic properties of atoms, and the mechanism of light-emission and of X-radiation. It would be a mistake to leave the impression that the whole problem of atomic structure has been solved. A most encouraging start has been made, but many questions remain unanswered and much research in this field is still to be made.

Petroleum Geology and Resources

PETROLEUM comes between natural gas on the one hand and coal on the other. It differs from natural gas in its more complex chemical structure and greater specific-gravity, though the two appear to have been derived from the same original sources. It differs from coal in origin, composition and form. Coal is derived from water-loving land plants, and in general accumulated in places in swamps. Oil and natural gas are believed to have been derived from seaweeds or lake weeds that, dying, settled to the bottom along with the remains of such animal life as inhabited the same waters. These, when mixed with the mud that settled at the same time, and deeply buried and compacted, became oil shales. Partial decay of this accumulated organic material may have converted some of it at once into oil. It is thought, however, that in general oil is the result of a natural process of distillation caused by later earth forces that compressed and heated the oil shales. Where the heating and compacting were of moderate intensity, the "kerogen," or accumulated weedy material, was converted into oil, and where the earth's action was more pronounced, gas was produced. Rocks that have been subjected to very great pressure and consequent heating uniformly lack oil or gas. Presumably, any kerogen originally existing in such rocks has been distilled off and dispersed.

Oil is not commonly found in oil shales but in porous-grained sandstones, limestones or other rocks. It is believed that, having been distilled from the kerogen in the oil shales, it tends to find its way to the surface in common with the general circulation in the earth's outer crust. Should it find direct passage upward, it emerges at the surface and evaporates. If, however, it encounters a barrier or a porous sandstone overlain by a non-porous layer, it will tend to accumulate in the pores of the sandstone or other rock, displacing any water that may be present and attaching itself by capillarity to the sand grains, which retain it against dislodgement.

There are known sources from which can be obtained sufficient oil for several hundred years. We may expect present methods of obtaining oil by drilling, combined with stocks in reserve, to keep pace with present needs for several years, probably five at least. We should look for a turn of the tide within the next 10 years, followed by a slow decline, with mounting prices which will be checked before reaching 45 cents by imports from South America and by the manufacture of oil from oil shale. What is beyond that is not of immediate interest.—G. H. Ashley, Pennsylvania State Geologist, at Oil Power Conference at Pennsylvania State College.

Vol. XXI October, 1927 No. 4

Aircraft Carbureters

By L. S. Hobbs[1]

Detroit Section Paper

Aircraft-carbureter design depends not only upon functional requirements, but also upon space restrictions which invite attempts to replace the carbureter with some device for injecting fuel or distributing rich emulsions of air and fuel.

Several causes are analyzed for reduction of size in proportion to capacity in spite of lower manifold-velocities.

Problems connected with cylinder multiplication and supercharger installation are discussed, including pre-heating of the charge, which is considered in connection with superchargers and air-cooled engines.

Increased ability of airplanes to fly rapidly and maneuver quickly has aggravated float-chamber problems.

Separate carbureters feeding the front and rear ends of 12-cylinder V-type engines suffer from pulsating suction.

Greater range is required in the carbureter and its controls because of higher engine-speed without corresponding change in idling speed, and because of higher performance-standards.

THE trend of aircraft-carbureter design is dependent upon both refinement in carburetion and the form assumed by engine and airplane development. One of these factors is more or less under the control of the carbureter designer; the other is not.

To some extent the design of the engine, and even of the airplane, determines the shape, size and general appearance of the carbureter; while the requirements of the device determine its interior construction. Obviously, the interior is limited by the form and size of the exterior, and the usual carbureter is a compromise built within the minimum possible space.

The distinctions are not, of course, clear-cut. Certain parts of the carbureter must be of a given size and form, and the engine designer is compelled to allow for them. Conversely, there may be requirements of the engine design which affect directly the interior construction of the carbureter.

There is considered here only the orthodox constant-head-suction metering-carbureter, which usually assumes the form of a combination of float-chamber, venturi restriction and spray nozzle. There are several experimental devices under consideration and some under test that are designed to replace this carbureter. Fuel injection is receiving a large amount of attention. There are various schemes for metering and distributing rich emulsions of air and fuel in ratios varying between 1 to 1 and 4 or 5 to 1, adding the remaining air at or near the ports of the individual cylinders.

The materiel division of the Air Corps has under test a gasoline fuel-pump and spray-nozzle. In this case the ordinary manifold-distribution scheme is utilized, and throttling for part load is effected by varying the stroke of the pump. The natural characteristics of the pump seem to care for full-throttle speed-variations over the range usually encountered in aircraft operation.

As will be noted later, there is a marked movement toward the so-called "rotary distributor," or a combination of this and a supercharger of the centrifugal type in one unit. This leads naturally to a single carbureter for the engine, and for the larger horsepowers the carbureter becomes bulky, although not out of proportion to the engine. It is here that the fuel-pump would seem desirable. There remain yet to be perfected details affecting idling, acceleration and mixture control.

Reduction in Size

Reverting to the design of the carbureter, the most marked external change within the last few years has been the reduction in size in proportion to capacity. An analysis shows several causes for this:

(1) In the water-cooled V-type engine, the horsepower advances have been made by enlarging the intake system to its maximum capacity, increasing the speed of the engine and enlarging the bore. Each of these changes has necessitated an increase in the size of the carbureter, while the last change has decreased the available space, since practically all V-type engines in this Country have the carbureter or the carbureters mounted in the V

(2) Both the air-cooled radial and the air-cooled V-type engine have worked toward a single carbureter for the entire engine. Primarily, this has been due to either rotary induction or supercharging, although in several cases multiple-cylinder radials have been furnished with a single carbureter and normal ring-manifolding. The decrease in size here is due both to the natural gain in compactness resulting from the combination of two or more carbureters into one, and to the absence of pulsations in the air-flow

With non-pulsating air-flow, maximum efficiency of the carbureter as regards capacity is obtained, although the gain from an increase above five or six cylinders is negligible.

However, the absence of pulsating air-flow has introduced a complication and an added part to the carbureter, as the effect of the pulsations was utilized in obtaining the desired mixture range. This range is roughly that of a mixture fairly rich at full throttle, becoming lean as the throttle is closed to give maximum economy at all cruising speeds. To obtain this in a plain-tube carbureter with non-pulsating air-flow, some sort of mechanically operated device is necessary. The mechanism in any of its various forms means added complication, and as actually used it has detracted from the appearance of the carbureter.

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It should not be inferred that the carbureter has decreased in weight in proportion to the reduction in size. The contrary is true. The addition of economizer devices, the use of packing glands to provide for supercharging pressure, larger float-mechanisms and float-chambers, and the substitution of stronger and heavier metal for duralumin in the throttles and shafts have all tended to increase the weight.

Problems with the Supercharger

The use of superchargers has compelled many changes and introduced several problems. With the centrifugal type, the carbureter may be placed on either the intake or the pressure side of the supercharger. The superchargers may be driven by gears or by an exhaust-gas turbine. For the Root's blower the normal installation has been to have the carbureter on the pressure side. When placed at the outlet of any type of supercharger some means must be provided to keep the pressure on the carbureter constant over the throttle range. This is a necessity because of the well-known change of mixture-ratio with change in density of the entering air.

It is possible that for any one given installation a natural metering-curve of the carbureter could be worked out to care for this change in pressure automatically so that the carbureter throttles could be used to throttle the supercharger. This would apply only to the centrifugal type, because in the usual installation the Root's blower is throttled by bypassing to the atmosphere.

When the carbureter is on the pressure side of the supercharger, it becomes necessary to provide packing glands to prevent vapor leakage at the controls or any points where there is a connection between the interior and exterior of the carbureter. Although negligible in amount, this leakage presents a serious fire hazard.

If the carbureter is placed on the intake side of the supercharger there is no necessity for tight joints, but the capacity of the carbureter must be increased in proportion to the capacity of the supercharger. A carbureter to supply an engine having a 20,000-ft. supercharger must be from 1½ to 2 times as large as that required for the same engine at sea level, according to the pressure drop allowed through the carbureter. Otherwise the carbureter functions in exactly the same manner as it would normally on an engine of larger size.

Both the rotary-induction system and the supercharging system with the carbureter on the intake side involve large volumes, including long manifolds between the supercharger and the cylinders, containing an explosive mixture. This means that when a cylinder backfires the resulting explosion in the manifold system is many times greater than is normally involved. It was found that the throttles and throttle shafts as previously constructed were entirely incapable of withstanding the high pressures generated, and it has been necessary to substitute steel for duralumin in throttle valves and shafts in these installations.

Fuel-Feed Control

There has been a general tendency toward the use of increased fuel-heads. This has put an added burden on the carbureter, because there is no proportional rise in the minimum head under which the carbureter is required to be capable of supplying the engine with its maximum fuel requirement. There is always the stipulation that no flooding must occur under any condition. The increased capacity of the carbureters and the higher fuel-heads have resulted in a double tendency toward an increase in float-mechanism size. In dirigible installations high fuel-heads are encountered, but these are easily cared for because the minimum head is proportionately high.

The general bettering of airplanes and engines during the last few years has produced a decided increase in performance. This has affected the carbureter in several ways. It has produced fast, maneuverable airplanes that fly at steep angles and change direction in an unbelievably short time. The carbureter is required to function at all times. To accomplish this, radical changes have been made in float chamber construction and in the method of taking fuel from the float chamber to the discharge nozzles.

Interesting and valuable data were secured by mounting in the cockpit of a maneuverable airplane a glass float-chamber fitted with a normal float-mechanism and containing red ink instead of gasoline. The liquid eventually reached practically every possible location in the float-chamber, and the changes in position were very violent. From observations of this it seems fortunate that engines will run fairly well on mixtures varying over a wide range.

Greater Flexibility Required

Another tendency in engine design has had its effect on the carbureter. As engine-speed is increased, there is generally an increase in spark-advance and valve overlap. The high-speed propeller is usually lighter than the corresponding slow-speed one. The consequent loss in flywheel effect has added to the idling difficulties. One of the requisites for the good landing of aircraft is an engine which will idle surely and smoothly at low speeds. These changed conditions have not affected the mixture requirements over the upper part of the range, but it is difficult to secure good idling with a large angle of spark-advance. Finely adjusted mixtures and accurate throttle-fitting are required, together with synchronization, if more than one carbureter is used. In passing, it seems that there is a considerable field for the development of a satisfactory and dependable automatic spark-advance for aircraft use.

As the over-all performance has increased, it has been necessary to give to the mixture control more range to care for the greater altitudes. This necessity has been added to by the more or less general practice of setting air-cooled engines for a specific fuel-consumption of 0.60 to 0.65 lb. per b.hp-hr. at full throttle on the ground. At altitude, with the decreased cylinder output and lowered temperatures, these engines will deliver full power and run well on specific consumptions of 0.40 to 0.46 lb. per b.hp.-hr. As the mixture control is adjusted by the pilot on the basis of engine power, measured by his tachometer, the net result is that the control range corresponding to a rise of 15,000 ft. or more is used before any correction is made for the increased richness due to lower air-density, and a corresponding additional range must be provided.

Ice in the Inlet System

The more general use of air-cooled engines and of rotary induction or superchargers has made more acute the problem of ice formation in the intake system, particularly at the carbureter, where it has always caused considerable trouble, even with the heated manifolds of the water-cooled engine. Complete data on this action are not available, but from observation two conclusions have been drawn. The trouble resulting from ice formation is greater during part-throttle operation than at full

throttle, and the ice formation itself is dependent mostly on the humidity of the air rather than on the temperature within the limits at which it will occur. The temperature factor becomes of more moment if benzol mixtures are used, because of the high-freezing point of this fuel with the tendency to form "benzol ice."

It seems possible that the difference between full-throttle and part-throttle operation is one of velocity. At full throttle the ice probably is carried away as rapidly as formed. The presence of this ice in the air-stream makes the problem particularly serious in the cases of the high-speed rotor of the supercharger and of rotary induction. Considerable damage may result from even a comparatively small piece of ice being thrown against a light aluminum rotor turning at 15,000 or 20,000 r.p.m.

Air-cooled engines are designed with the maximum cooling effect possible, not only for the cylinders but also for the crankcase, as the primary consideration. This is necessary because the engine must operate under conditions of high temperature in summer. In winter and at great altitudes the induction system suffers.

The heating media available for water-cooled engines are exhaust gas, water and oil; and for air-cooled engines, exhaust gas, oil and warm air from the cylinders. Oil has been tried and its effect appears to be far from adequate. The evidence seems to show that the oil next to the cooling wall becomes cold and rather viscous, thus forming an insulating layer over which passes the circulating oil with little heat-transmission taking place. Hot water is in more or less general use now on manifolds and, could a sufficient area of jacketing be obtained, it would no doubt be entirely successful. The increased weight and complication due to water-jacketing are rather great. Warm air from air-cooled cylinders will aid greatly, but it is very doubtful if extreme conditions can be cared for in this manner.

Exhaust Gas for Heating the Intake

Exhaust-gas heat seems to present the greatest possibilities. It is available at all times and in any quantity desired; and, by the use either of a simple flapper-valve or of the manifold vacuum, the quantity can be regulated as desired for any condition. There are objections, however, particularly with the in-line or the V-type water-cooled engine. It is a very difficult problem to get the exhaust gas of the usual engines of these types from the exhaust side to the intake side without a complicated piping arrangement that will take up much-needed space and require heat-lagging. In the case of the siamese-ported engine, this objection disappears. One of the best known of the present aircraft engines is of this type and is utilizing this heat with success. In this particular instance the manifold vacuum is used to regulate automatically the amount of heat for different throttle-positions.

The best point for applying the heat has not been determined. Upon first thought it would seem logical to do this at the carbureter where the refrigeration takes place, but the objections to this are in some cases insuperable. The space available is usually so limited that, as previously explained, much crowding is necessary to incorporate the necessary parts of the carbureter. To do this, these parts have been shifted and arranged so that there is an astonishingly large number of drillings, plugs and passageways. Even if the room were available, placing a jacket around these would be a designing feat requiring not a little skill; and under the best conditions it would present difficult casting problems to the foundry.

With heat applied at the carbureter, there is always danger of boiling the fuel in the float chamber, with consequent erratic operation, if care is not taken to regulate closely for varying temperature conditions. Where possible the use of a warm-air jacket similar to a water-jacket around the intake-manifold system will probably give good results. This, like the water-jacket, involves not a little added weight and casting complication.

A Hot-Spot above the Carbureter

I am of the opinion that, under present conditions, a short vertical "hot-spot" immediately above the carbureter offers the best solution of the problem of heating the mixture. Its inherent advantages are many. It may be made of light sheet-steel which will stand the necessary temperatures and is cheap to manufacture. By using high temperature-differences it can be made small, and the weight will be much less than that of cast jackets. The vertical construction gives a partially automatic control of the mixture temperature. When liquid fuel is present the heat is applied directly to it, while the vaporized portion passes with only a slight contact and with the minimum rise in temperature.

Observation indicates that the objectionable ice-formation is greatest on and around the throttle valves and shafts, as might be expected. Vaporization of the fuel is gradual, going on continuously from the time the air and fuel first meet, probably being accomplished most rapidly at the point of the first real mixing of the two. Because of the high velocities existing, this point is undoubtedly beyond that where the fuel is sprayed into the air-stream, probably about at the throttle valve. Also, the throttle and its shaft, passing directly across the stream, offer the first surface for deposit with which the major portion of the mixture comes in contact. The high temperatures will cause a flow of heat through the metal of the flange and the upper portion of the carbureter by simple contact. As at present constructed, carbureter throttle-valves of the butterfly type protrude above the upper flange-surface, and the throttle shaft is only a short distance, usually from ¾ to 1 in., below. If necessary, the gasket can be omitted and the flange surfaces bolted directly together.

Pre-Heating versus Maximum Power

Discussion of ice formation leads directly to the consideration of proper vaporization of the fuel. It is generally agreed that the ideal condition for proper distribution is that of a perfectly homogeneous gas. The most practical method of getting the mixture to approach this state is by the use of heat. Mechanical vaporization or atomization of the fuel seems not to be a success, for, even though a perfect fog is secured from an atomizing device, the liquid immediately settles out again.

Balanced against the addition of heat is the primary consideration for all aircraft engines; that is, maximum power. Obviously the result must be a compromise. In practice, heat can be used with only a slight sacrifice of power, as only a small amount of heat is required or desirable at full-throttle operation. An aircraft engine is normally used as little as possible under maximum-power conditions, and an optimum fuel economy is not then of the order of importance that it is within the cruising range. The problem of detonation also makes obligatory the minimum inlet-temperature under full throttle.

As has previously been noted, ice builds up least at full throttle. High manifold-velocities are a material aid in obtaining the required distribution. The enlargement

of the induction system and carbureter with the constantly increasing engine performance has been out of proportion to the increase in flow through them and this advantage may disappear.

Rotary-induction systems and superchargers help in the vaporization of the fuel. Maximum power is at the will of the designer and the natural temperature rise through the system aids vaporization. It is questionable whether there is any gain from mechanical atomization. Assuming the production of a vapor or fog, two problems remain: to prevent the deposition of ice, and to keep the liquid fuel from settling out after it leaves the rotor.

More Heat at Part Throttle

At part throttle the conditions change. Best distribution is the primary essential, the requirement of full power and the liability of detonation being absent. The temperature rise can now be ample to give vaporization and to keep the induction system warm, preventing ice. From this it is evident that some sort of control for the heat is necessary, and the form this should take is a subject for some research and experimentation.

Two factors which greatly affect the matter of heat application have not been considered. These two factors, really one in their effect upon the present problem, are the grade of fuel and the average air-conditions under which the carbureter is to operate. A casual consideration leads again to the conclusion that the heating unit must incorporate a means of control.

In considering the carbureter, it is of interest to take account of the effects of different types of induction system. There has already been mentioned the trend toward larger and more manifolds and carbureters of greater capacity. With the plain-tube carbureter this means operation under lower suctions; and this, with variations, is the only type acceptable for aircraft use with our present knowledge. The idling system must be of greater range and the problem of acceleration, or response of the engine to a sudden opening of the throttle, becomes increasingly difficult. The actual time required by the engine to obtain full speed is so short that any variation during acceleration is negligible, so long as all the cylinders fire.

The violence of pulsations in the air-flow is dependent, not only on the number of cylinders drawing, but on the size and arrangement of the manifold. These pulsations affect the carbureter metering, and merely changing the length of manifold will change the effect. Normally, if six cylinders draw from a single barrel, the pulsations are well dampened out due to the overlap. However, if six cylinders on one end of a 12-cylinder V-engine are connected to one barrel, the pulsation effect is rather large, because any acceptable firing order will have two cylinders on one end drawing consecutively, after which there will be an interval during which two on the other end are drawing.

Observation of exhausts of several different makes of engine in which manifolds are wholly or partially connected from bank to bank seems to show that this arrangement makes one bank operate differently from the other. Whether this difference is one of power or of distribution is a question. However, if of distribution, the difference must be negligible, for the fuel consumptions obtained are on the average as good as with other systems.

Several special constructions seem possible and practical for the future. As antiknock compounds come into general use it may be found necessary for economy to mix them with the fuel only as required for full-throttle operation, and the carbureter can be made to do this. Another problem is the incorporation of a means of utilizing the waste hydrogen-gas "valved" from dirigibles.

Quantity Will Permit Needed Differentiation

The aircraft carbureter has been considered generally with no regard to its specific use or conditions of service. Because of the limited demand it has been manufactured in more or less the same manner. The average life of an aircraft-carbureter model is about 2 years. The small production does not allow of the minor refinements of simplification which would follow if each model were designed only for a specific use, eliminating features, sometimes very complicated, that are necessary only for other types of installation.

Two general classifications of carbureter may be assumed: military and commercial. This gives a rather happy division, as the basic demands are entirely different. One of the essentials of any military aircraft is to allow the personnel to perform other tasks with the maximum freedom from operating duties. Commercially, the requisite is the performance of a certain duty at the smallest possible cost. The demands of the two overlap in many places, but the general tendencies of the first are toward automatic regulation, which means complication, and of the other, toward simplicity. Military service demands the maximum performance; commercial service will sacrifice performance if a saving can be accomplished thereby. Eventually, as production increases, there will be other classifications, and this should allow of simplification of designs intended for either military or commercial use.

A quantity demand also would lower manufacturing cost. With the carbureter crowded into the minimum space it is not possible to provide clean designs with the minimum of machining and drilling operations, nor to make the necessary operations all straightaway. Despite the requirements of material and workmanship, there is no reason why aircraft carbureters should not be made by regular production methods, slightly modified.

I do not mean in any sense to deplore the effect of the military demands on carbureter design; quite the contrary. The basic principle which is right for a military design is, possibly in a simplified form, right for any design. The military is the extreme in requirement and serves as a criterion for performance. A good example of this is the increase in maneuverability already mentioned. Commercial airplanes never will require the extreme maneuverability required for fighting, but the carbureter developed for this can now be used commercially with proper functioning in rough-weather flying and for taking-off from rough fields or rough water. What aircraft-carbureter development there has been in this Country is due almost entirely to military demands.

Vol. XXI October, 1927 No. 4

The Constantinesco Torque-Converter

By R. K. Jack[1]

Annual Meeting Paper *Illustrated with* Drawings

THE purpose of the mechanism described is to produce an instant and automatically variable torque that is always equal to the resistance encountered while the primary driving engine maintains its speed and torque nearly constant.

The principle of operation is illustrated by reference to the action of a stick weighted with a ball at one end and suspended freely by a string at the other so that it can swing as a pendulum. Interference with the swing of the pendulum at any point on the stick results in a transference of part of the inertia force of the ball to other parts of the stick and also alters the amplitude and rate of vibration of all parts. At the same time, pressure is set up at the point of interference. The pressure varies in magnitude with the inertia and is proportional to the change of speed in a unit of time. In a motor-car the engine, which develops a steady pull or torque at a constant speed, is used to drive against a resistance that requires either a variable torque or variable speed. The mechanical means employed to provide this variable torque can be reduced to the principle of the lever, in which varying the point of support changes the pressure required at one end to balance a constant weight at the other end. In practice in a motor-vehicle, this is accomplished by a change of leverage, or ratio, by shifting gears.

Time is another element that enters into the problem. It is possible to transfer more or less force to a given point by altering the frequency of oscillation. Moreover, whereas with an ordinary lever a steady pressure at one end will maintain a steady pressure at the other end, this condition cannot be reproduced with the pendulum unless the system is permitted to accelerate indefinitely. The same result can be secured, however, by alternating the pressure on opposite sides, and the pendulum will maintain a mean position. Similarly, rotary motion cannot be transmitted from one shaft to another except by periodic alternating impulses, which is exemplified by the periodic impulses transmitted by the teeth of gears and also by the alternating electric current.

These facts are made use of in the Constantinesco mechanism, in which an inertia system is interposed between the prime-mover, which imparts an alternating motion, and a system of "mechanic valves," or roller-type irreversible clutches, which convert the alternating motion into rotary motion. Close similarity exists between this mechanism and electric transmission, as it splits the motion derived from an alternating crank into two components, one applied to a mechanical inertia element and the other into a resistance. These forces are analyzed with formulas.

Application of the torque-converter to a 5-hp. car and its automatic action under driving conditions are described. It functioned perfectly when the author drove the car, which was so simple to control that he believes engineers should give much attention to this transmission.

In discussion of the paper comment is made that power imparted to the engine flywheel prior to starting the car is not immediately available to overcome the resistance, and that this would be disadvantageous when a quick start was required. Efficiency of the transmission is said by the author to have been proved by tests to be approximately 80 per cent for 1 hp. transmitted and that at full engine-power the efficiency should be very high. In the small car virtually no vibrations of any kind were noticeable, and the author asserted that the inertia forces of the torque-converter do not impose undue pressures on the engine bearings. A description is given by one speaker of a somewhat similar torque-converter patented in this Country which is constantly in balance and which, judged from the mathematical angle, is the most perfect power-transmission mechanism conceivable.

THE torque-converter herein described is the invention of George Constantinesco, who is the inventor of a system of synchronized rapid-firing between the blades of an airplane propeller which was used considerably during the World War. He supplied me with information regarding his torque-converter, and after driving his car in London and visiting his laboratories, I pass the information on to members of the Society.

The purpose of the converter is to produce an instant and automatic torque that is always equal to the resistance encountered, while the primary driving-engine maintains its torque and speed nearly invariable. Incidentally, this opens a large field for the application of this machine.

To explain the principle of the mechanism, let us take, for simplicity, a stick and on one end attach solidly a ball, or mass, to form a pendulum. If the free end of this pendulum is hooked to a support, we interfere with the free fall of the pendulum and a certain load or pressure is exerted on the hook. This we can easily verify if we take the hook in our hands, as we can feel this pressure. After having restrained the natural fall of the pendulum in this way, suppose we give it a swing. The pendulum will continue to swing for a certain time and at a certain frequency of its own choice. We may now consider this to be a new state of affairs, which, if interfered with again, will create other pressures. For instance, if I put my hand in the path taken by the ball during its swing, I shall at once feel a heavy pressure and at the same time observe a deformation of my hand and a change in the movement of the ball.

There are many ways of interfering with the natural movement of this pendulum and any interference with it will produce a pressure. Suppose I grasp the stick,

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instead of the ball, at some point between the hook and the ball. I can interfere as much as I care to with the free swing of the pendulum but when I do so I feel a pressure on my hand which changes continuously. For example, if I try to swing the ball faster than it chooses to swing, my hand will feel an increasing alternating pressure. Now suppose I unhook the stick from its support and hang it on a piece of string with the ball stationary, as at the upper left in Fig. 1. If I interfere with this state by oscillating the stick the ball will remain practically where it was before, while the free end of the stick oscillates from one side to the other. While doing this, suppose some other force interferes with this new state of affairs; for example, that my left hand holds the top end of the stick. According to the former explanation, my left hand will immediately feel the pressure due to the new interference and it will be necessary for my left hand to exert a muscular effort to bring the free end of the stick to rest. As soon as my left hand succeeds in doing this, I shall feel an extra pressure on my right hand also, and the ball will take a new movement of a large amplitude, as at the upper right in Fig. 1. This experiment shows again that any interference with the condition existing at any moment produces an over-all change in many other ways. The interference of my second hand in holding the top of the stick results in a pressure in my left hand and extra pressure in my right hand, and in setting up a new motion for the pendulum.

Interference with Movement Transforms Forces

This simple mechanism of a pendulum is a ready means by which we can transform forces, and the method by which forces are changed is, in reality, very simple. To accomplish this it is sufficient to produce a movement of one part of any system and then interfere with the natural movement of another part. For instance, if we hold the stick at some intermediate point and give it a certain alternating motion, as by shaking it, the natural motion of the ball and stick will be a fairly large oscillation of the free end of the stick and practically no movement of the ball, as at the lower right in Fig 1. If we interfere with this state and try to restrain the end of the stick, as by attaching it to some machine or to a resistance of some sort, a new state of affairs is created and forces and pressures are transferred to the point of impulsion and the point of resistance.

We know that the pressure due to interference with the movement of a body varies in magnitude with the inertia of the body, and that inertia is a property of bodies by virtue of which any interference with their speed results in a pressure or a force. From experience we find that if one attempts to change the speed of an object, the force required to obtain this result is proportional to the change of speed in the unit of time, or acceleration, and to a certain coefficient which we shall call inertia. But such a simple relation is far from being correct if the body which we have under consideration is not free but is entangled with interferences. For instance, if we move the pendulum by imparting a force on part of the stick while the free end is held or attached to some machinery, the calculation of the forces at the point of impulsion is not so simple. The solving of such a problem is the foundation on which the torque-converter is constructed and is necessary before such a converter can be made workable.

The traction problem may be stated as follows: An engine which can develop a steady pull at a constant speed has to be used to drive against a resistance which requires a variable pull or a variable speed. From this definition it is obvious that the engine must be connected to some intermediate machinery which will change the form of the energy supplied by the engine to some more convenient form applied to the resistance. The problem has been approached in many ways, as by using gear-boxes, hydraulic transmissions, electric transmissions, friction discs, and other forms of mechanism by which it is possible to alter conditions between the driving engine and the resistance in a suitable way so that the work can be performed while maintaining a steady pull and a constant speed of the engine. The mechanical means by which solution of this problem has been approached can be reduced to a very simple foundation; namely, to the principle of the lever.

How Leverage Transfers Varying Forces

Let us now consider how a lever works. Suppose we have a horizontal stick with a heavy ball at one end and at some intermediate point we have a support. If we do not disturb the existing state, the system of ball and stick will take a natural movement, the ball trying to fall down and taking with it one end of the stick while the other end of the stick will rise. Suppose that, before this movement occurs, we interfere with it by taking hold of the free end of the stick to prevent the fall of the ball. Immediately a force will become manifest at this end. It could be replaced by a weight which, if left alone, would also try to fall to the ground. The weight interferes with the free movement of the stick, the stick interferes with the free fall of the ball, and a new state of affairs is produced. When a state has been established in which the relation of the ball, the weight, and the position of the support is such that neither the ball nor the weight can fall, the system is said to be in equilibrium.

This simple piece of mechanism therefore provides a ready means of obtaining heavy forces from light forces by simply changing the point of support along the stick. One element, however, must be borne in mind when using this simple mechanism: If we have decided to put the point of support at some chosen place, only one definite force must be applied at the end of the lever to balance a given resistance at the other end. Therefore, if the resistance changes we must change the force on the end of the lever; or, alternately, if the force on the end of the lever cannot change, we must change the point of support. This involves the use of judgment and skill by the individual who handles the lever. For example, in a motor-car the driver must exercise skill and judgment when changing gear to climb various gradients. Is it possible to dispense with the necessity of this skilled interference between a driving force and a variable resistance? We are so accustomed to regarding the intervening of personal mechanics as necessary when a car experiences a sudden change of load that the use without such intervention of an engine which has a constant pull and constant speed to drive against resistances which may vary widely seems to be a remote possibility.

The elimination of human interference for the adjustment of the leverage is precisely the object of the torque-converter. It is apparent, therefore, that such a machine must use some principle other than that of the ordinary lever, which definitely requires intelligent interference with the position of the point of support with relation to the driving force and the resisting load.

Time Element Alters Magnitude of Force

We shall now revert to the stick with the ball at one end and suspended on a string. We have seen that by

simple interference with the natural movement of this mechanism it is possible to establish forces at the free end of the stick. Such a mechanism differs from the ordinary lever, which works independently of the consideration of the element of time. I have not previously mentioned time when explaining how it works. A small weight can raise a heavy weight by the use of an ordinary lever and the selection of a proper point of support, or fulcrum, for the lever. With the mechanism of a ball and stick, if we move the stick slowly very little pressure is created, whereas if we move it fast a considerable force is created. This brings us to the solution of our problem. To alter the magnitude of forces it is sufficient to introduce this new element of time into the operation of the mechanism. Instead of altering the point of support, as on an ordinary lever, we have no point of support and alter nothing but the frequency of oscillation. We have the possibility, therefore, of producing a light force or a heavy one at a given point on the stick by simply moving the stick to and fro with a slow or a fast movement.

The other difference between the use of an ordinary lever and this mechanism which becomes manifest is that, whereas, with an ordinary lever one can produce a steady pressure on one end to maintain a steady pressure on the other end, we could not reproduce this effect with the pendulum. Thus, if I press the stick in one direction, an acceleration of the whole system follows and it will be impossible to maintain the steady pressure on the stick for any length of time in one direction unless the system is permitted to accelerate indefinitely. On the other hand, it is possible to alternate the pressure in opposite directions as many times as I like, and the pendulum will maintain the same mean position. Whereas in the ordinary lever we have an embodiment of steady forces without relative movement, in a pendulum oscillated forcibly at a certain rate we have a steady frequency and an alternating or vibrating pressure. To dispose of the objection that it does not seem right to use vibrations for the purpose of transmitting rotary power, it is necessary to make the following observations:

Rotary Motion Transmitted by Periodic Impulses

Rotary motion cannot be transmitted from one shaft to another except by periodic, or intermittent, impulses. For instance, if we use a pair of gears the rotation of one shaft is transmitted to another shaft by periodic impulses given to the teeth of one wheel by the teeth of the other. Each tooth in succession is subject to a pulsating pressure which starts from zero, reaches maximum, and goes back to zero. Then another tooth takes its place, and the same cycle is repeated. If we attempt to drive one shaft from another through a belt, rope, hydraulic transmission, electric transmission, or in any way, it will be found in each case that the transmission medium is periodically strained and relieved, and the energy must pass from one shaft to the other in pulsating or vibrating form.

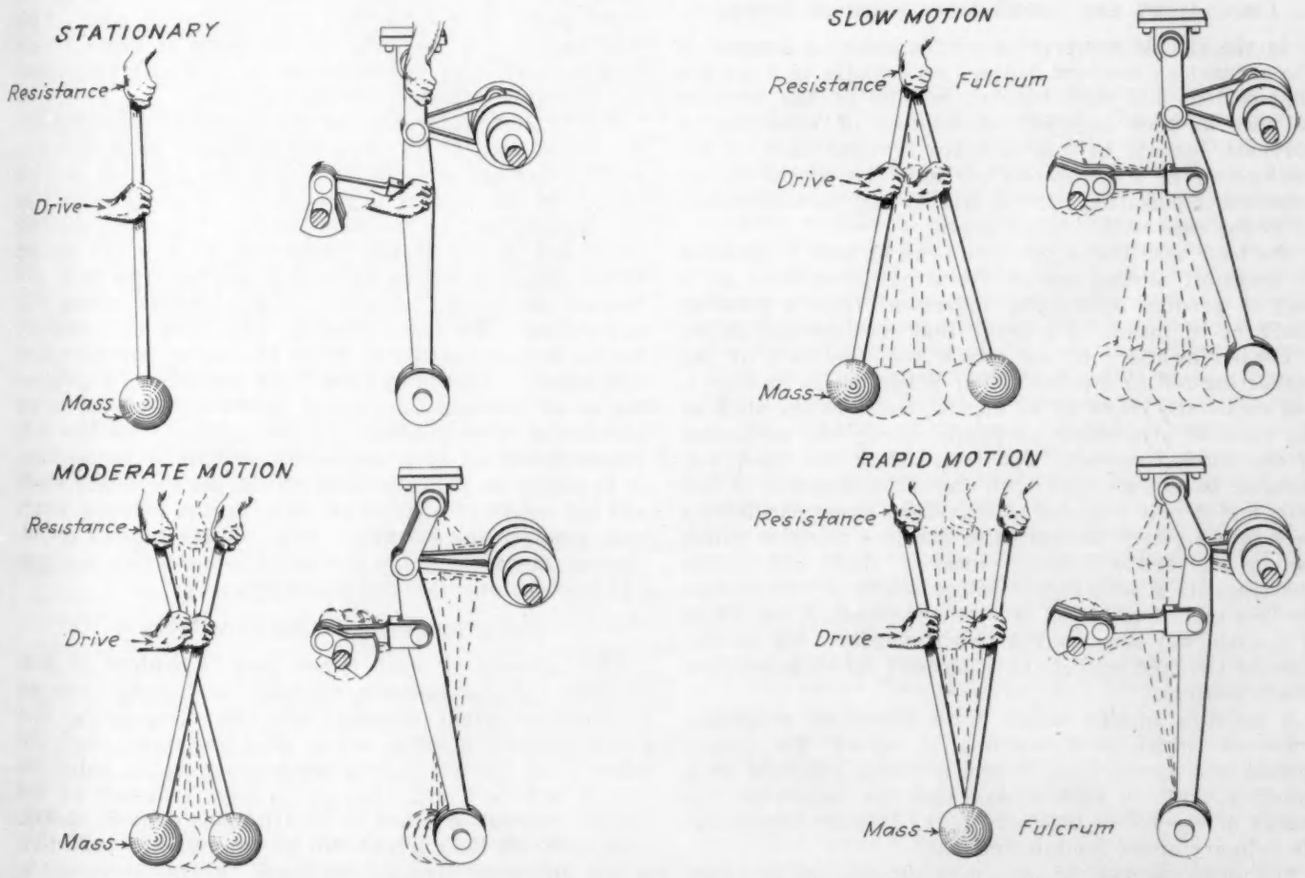


Fig. 1—Diagrammatic Comparison of Action of a Simple Pendulum with That of the Torque-Converter

(Upper Left) Pendulum and Converter Elements in a State of Rest. (Upper Right) Inertia Mass Oscillated Slowly by Impulses between Secondary Point of Support and the Inertia Mass. (Lower Left) Secondary Point of Support, or Resistance, Set in Motion by Moderately Fast Impulses, and Amplitude of Oscillation of the Mass Reduced. (Lower Right) Speed and Amplitude of Secondary Point of Support Increased and Mass Brought to Rest by Rapid Impulses of the Drive between the Two Points

Furthermore, all methods of transmission can be divided into two large groups. In the first group, the energy may be transmitted by circulation of a medium in a circuit. This means that through a given section of the transmitting medium a current is passing in one direction only. For example, in a pair of toothed gear-wheels the medium of transmission is the teeth, which are circulating at a certain velocity and producing a current of a given number of cubic units of material in a unit of time. A belt, an hydraulic pipe-line, a rope circulating in a similar manner, and a continuous-current electric transmission are examples of the circulating type.

In the second group the energy is transmitted by the oscillation of a medium so that, through a given section of the medium, the current passes alternately in both directions. The ringing of church bells by a rope, the transmission of rotary movement in locomotives through reciprocating connecting-rods, the electric alternating-current transmission, and the transmission of sound at a distance through air or by wireless waves are examples of the oscillating type.

Thus it is seen that rotary motion cannot be transmitted unless the power takes the pulsating form at some stage. It seems, however, that there must be some fundamental difference of action between the circulatory and the oscillatory methods of transmitting power. According to the postulate defined, both methods must use periodic impulses; the difference consists only in the method by which the impulses are delivered.

Circulatory and Oscillatory Methods Differ

In the circulatory type of transmission, a portion of the circulating medium delivers an impulse in a certain time-period, and then another portion of the medium delivers another impulse. A number of elements, or portions, operate in turn and are brought back by the mechanism in a continuous stream; the action of the elements is pulsating but the stream may be continuous, as is the case with toothed gears.

We have seen that a pendulum can be used to produce or transmit alternating or vibrating pressures. It is easy to produce alternating movement from a rotating shaft, as by means of a crank that revolves and drives a connecting-rod. If we attach the free end of the connecting-rod to a point of our pendulum as in Fig. 1, and rotate the crank by an engine, we force the stick at the point of attachment to follow exactly the movement of the connecting-rod. The free end of the stick will oscillate in synchronism with the connecting-rod if left free, and it only remains to transform these oscillations back into a rotary movement to obtain a machine which has on one end a primary rotating shaft and at the resisting end a secondary rotating shaft. If we connect the free end of the stick to a pair of ratchets, we obtain in a crude way an apparatus which converts the oscillations of the free end of the stick back into intermittent rotary motions.

A machine in this simple form represents a torque-converter, which is a machine to convert the torque applied to a primary shaft into a torque collected on a resisting shaft in such a way that the resistance can change between wide limits while the primary torque and the primary speed remain constant.

The term "ratchet" is not a very suitable one by which to designate all the varieties of apparatus which can transform oscillations into continuous rotation. It conveys to the mind the idea of a device that acts in a series of jerks. Although such a jerky ratchet can be used for a very crude demonstration of the principle of the converter, in reality some better mechanism must be used which will smoothly transform oscillatory forces and movements into continuous torque and rotation. Because of analogy with the hydraulic valve, which performs a similar function in transforming an oscillatory current of fluid into a continuously flowing stream, and with the "electric valve," which performs the same duty with alternating electric current, Mr. Constantinesco has given the name "mechanic valve" to this part of his apparatus, which can transform vibration into continuous movement and continuous torque.

Elements of the Torque-Converter

The torque-converter, therefore, consists of an inertia system interposed between a prime-mover, which imparts to it an alternating motion, and a system of mechanic valves which interfere with the natural movement of some part of the inertia system. It is in principle a machine which transmits the torque obtained from a steadily rotating primary shaft to a secondary shaft by splitting alternating motion obtained from the primary shaft into two components, one applied to an inertia and one applied to mechanic valves which convert alternating movement and impulses back into rotary motion. The majority of ordinary mechanisms which have been considered by generations of engineers are machines with one degree of freedom. This means that, if we impart a certain displacement to some part of the machine, all the other parts of the machine will be definitely displaced also; and, if we stop any of these displacements, all the other parts of the machine will be stopped also. This will happen, for instance, in any train of gears, chain transmission, link transmission, or machine employing the hydraulic principle for its operation.

But in electrical machinery the conditions are different. We know that, if we turn the armature of a dynamo, electric current is produced which can drive an electric motor; in this way it is possible to rotate the shaft of the dynamo and, by the combination of dynamo, electric wires and electric motor, rotate the shaft of the motor. If the armature of the dynamo is started from rest and rotated slowly, the armature of the electric motor will not rotate. We must speed-up the dynamo armature until a state is reached in which the motor armature also will rotate. Such a machine has, therefore, a greater degree of freedom than exists in the case of the usual mechanical transmission. The torque-converter has this characteristic of such an electric transmission because, if we rotate the primary shaft slowly, the secondary shaft will not rotate at all. When rotating the primary shaft fast, however, the secondary shaft will start going round. One can see, therefore, a similarity between this mechanical machine and electric transmission.

Force Split into Two Components

This analogy is much closer than is evident at first thought. If, for example, we split the current from an alternating-current dynamo into two components, one going through a lamp acting as a resistance and the other to an electric inertia-device, such as an induction coil, it will be found that, for a low frequency of the electric current obtained by rotating the dynamo slowly, practically all the current will go through the induction device and none through the lamp. If the frequency is raised by rotating the dynamo faster, the current will pass in preference through the lamp instead of the induction device. In this example the only element we change is the frequency of the electric current. This

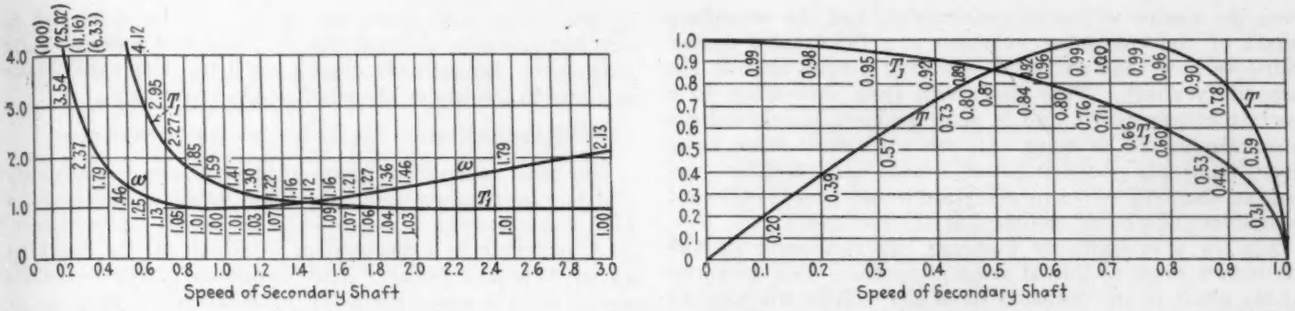


FIG. 2—VARIABLE TORQUE GIVEN BY THE CONVERTER ON THE SECONDARY SHAFT WITH VARIATION OF SPEED OF THE SECONDARY

The Diagram at the Left Is for Constant Torque of the Primary Shaft, and That at the Right for Constant Speed of the Primary. Curve ω Is Speed of the Primary Shaft, T Torque of the Primary, and T_1 Torque of the Secondary. When Torque of the Prime Mover Is Maintained Constant, the Energy Is Greatest for Low Speeds and also for High Speeds of the Secondary, whereas for Intermediary Speeds the Energy Is Minimum. When Speed of the Prime Mover Is Maintained Constant, the Energy Is at Its Maximum only Toward the Higher Speeds of the Secondary. Ordinates in the Diagram at the Left Represent Minimum Speed of the Prime Mover in Unity and Multiples Thereof. To Find Any Desired Engine-Speed on the Curve ω, It Is Necessary only to Multiply the Ordinates by the Normal Speed of the Engine in Revolutions per Minute; thus, if the Normal Speed of the Engine is 2000 R.P.M. and the Minimum Speed Is 1200, the Ordinates Are Multiplied by 1200. The Abscissa Express Speed of the Secondary in Tenths of the Speed of the Vehicle. If the Vehicle Speed is 20 M.P.H., a Secondary Speed of 1.0 Represents a Vehicle Speed of 20 M.P.H.; therefore a Vehicle Speed of 6 M.P.H. Is Represented by 0.3 in the Abscissa. Corresponding to This, on the Curve ω, Is the Number 2.37, Which, Multiplied by 2000, Equals 4740 R.P.M. On the Curve T_1 Is the Corresponding Number 11.16, Which Represents 11.16 Tons if Unity Represents on Curve T_1 the Normal Torque, T_n, Corresponding to 1 Ton

In the Diagram at the Right, the Scales of the Torque, T_1 and T, Have Been Selected so that the Starting Torque Represents the Unit for Measuring the Secondary Torque. To Obtain the Torque T_1 on the Secondary for Any Given Speed on the Secondary Shown as Abscissas, the Corresponding Numbers on the Ordinate of the Curve T_1 Must Be Multiplied by the Value of the Starting Torque. The Same Applies to the Curve T, the Corresponding Numbers on Which Must Be Multiplied by the Maximum Torque on the Primary Corresponding to the Particular Constant Speed ω Which Was Selected

shows again that in an electric machine the element time plays a very important part.

If we now consider the converter, which splits the motion derived from an alternating crank into two components, one applied to a mechanical inertia and the other to a resistance, we find that, for a low frequency of oscillation obtained when we revolve the primary shaft slowly, movement occurs only in the inertia device, while the resisting end remains stationary. If we increase the frequency of oscillation we find that the movement takes place at the resisting end, while the inertia system tries to become stationary. In the electric machine, if we call I the primary current derived from the dynamo, I_1 the current branched to the lamp or the electric resistance, and I_2 that branched to the induction system, then

$$I = I_1 + I_2 \qquad (1)$$

If the difference of electric pressure at the dynamo end is represented by E, and L represents a constant depending on the electric inertia, or what is called induction, a relation exists between L, E, I_1 and time which can be expressed by the formula.

$$E = L\,(dI_1/dt) \qquad (2)$$

Now, if we represent by the symbol V a quantity proportional to the speed of the motion obtained from a primary crank, and split this quantity into two components; one, V_1, applied to a system of mechanic valves driving a resistance, and another, V_2, applied to an inertia element, we can write $V = V_1 + V_2$. Also, if the pressure in the primary connecting-rod is represented by P, and K represents a constant depending on the inertia, a relation exists between K, P, V_1 and time, t, which can be expressed by the following formula:

$$P = K\,(dV_1/dt) \qquad (3)$$

One is immediately struck by the identity of the formulas in these two widely different mechanisms; on one side an electric machine, an electric resistance, and an electric induction-coil, and on the other side a primary rotating crank, an inertia, and a mechanical resistance. On proving this, Mr. Constantinesco was able to design his converter as if it were an electric machine and succeeded in drawing the whole of the torque and speed curves of this converter before it was built.

INERTIA ELEMENT ADJUSTS ITSELF TO RESISTANCE

The rotary movement of the prime-mover is first transformed into a vibratory movement. This primary vibration is then divided optionally into two components of variable amplitude, one applied to vibrate an inertia and the other transformed back into rotary motion by suitable rectifiers, or what we have called mechanic valves. The whole mystery of this invention lies, therefore, in the useful harnessing of a free vibrating inertia-element between two rotating shafts, and this produces forces and pressures when we interfere in any way with the natural movement of the inertia element. Assume that the prime-mover rotates steadily with a constant torque applied to it, and that the secondary rotating shaft of the converter drives some machine offering a certain constant resistance. In this situation the inertia weights will vibrate at a certain amplitude. Assume now that for some reason the resistance has become much greater; this will have a tendency to reduce the speed of the secondary shaft and therefore the amplitude of the vibrations of the mechanic valves will be reduced. But this is followed by an increase of the inertia's vibrations, or this interference with the previous state of the vibrating inertia weights produces at once an increase of pressure on the valves that automatically overcomes the extra increase in the resistance.

In a car fitted with a torque-converter, instead of the driver interfering intelligently by changing gear to obtain the proper ratio, the mere increase or decrease in resistance encountered by the car suffices to cause the vibrating inertia weight to at once automatically make the necessary adjustment by correspondingly increasing or decreasing the torque that drives against the resistance. Since this is so, and assuming that we drive the primary shaft of a converter with a constant-torque engine, it can be seen that if the secondary shaft is left

free the engine will accelerate rapidly and the secondary shaft of the converter will also run faster and faster. Suppose now that we put a resisting torque against the secondary shaft. This shaft will then slow-down to a certain steady speed, and in such a condition will deliver a certain amount of work. All this work must come, however, from the primary power source and therefore the engine also will settle to a certain lower speed, sufficient to deliver the power absorbed at the secondary.

Let us now suddenly increase the resistance of the secondary shaft so that it stops altogether. As the speed of the shaft is nil, the work done also will be nil, but the engine will still develop a constant torque and the power must go somewhere. Since the converter wastes only a negligible quantity of power in overcoming its own internal friction, virtually all of the power goes to accelerate the flywheel of the engine, thereby increasing the frequency of the vibrations of the inertia weights. This creates an ever-increasing pressure on the mechanic valves and results in an ever-increasing torque on the secondary shaft. In such circumstance the speed of the engine may become infinitely great, while the torque on the secondary shaft may also become infinitely great. Soon or late this secondary torque will become so great that it will overcome any resistance. If, however, we now diminish the resistance on the secondary, this shaft will rotate faster and therefore power will be delivered in driving against the resistance. This will automatically slow-down the primary engine until its developed power is equal to the power absorbed at the secondary.

Mathematical Analysis of the Converter

The mathematical analysis of the converter is not easy and has been arrived at only after years of research by Mr. Constantinesco with variable-speed transmission. The converter is a mechanism in which all the working parts, save the primary and secondary shafts, oscillate about certain mean positions with harmonic motions of the same frequency. All such parts are subjected to internal forces which are also harmonic and have the same frequency. If the angular speed of the prime-mover be α, every displacement, velocity, or force in the mechanism can be expressed by a relation of the form

$$x = s \sin (at + \Psi) \qquad (4)$$

where

a = the angular speed of the primary shaft
Ψ = a certain angle of phase
s = the amplitude of such variable
x = a distance traveled, a velocity, or a force as the case may be

By definition and construction the converter is an apparatus that splits the harmonic motion derived from

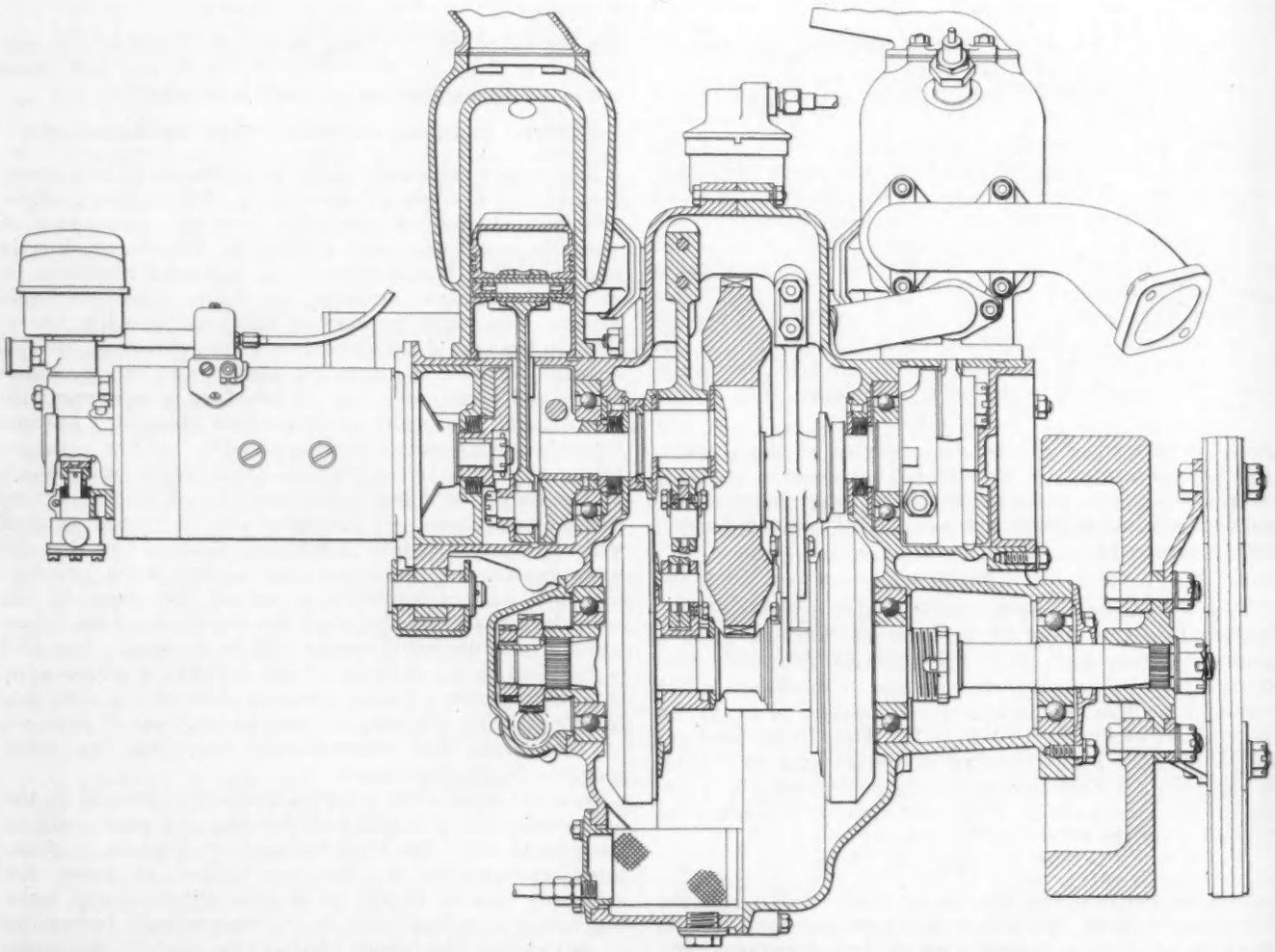


Fig. 3—Powerplant and Transmission in Longitudinal Section

The Torque-Converter Flywheel Is Carried in the Center on the Engine Crankshaft and Two Short Cranks or Eccentrics on the Shaft Oscillate the Two Inertia Elements on Either Side of the Flywheel. Below Is the Secondary Shaft, Which Is Driven by the "Mechanic Valves" and in Turn Drives the Propeller Shaft through a Flexible Coupling at the Extreme Right

a steadily rotating primary shaft into two components. One component is applied to a mass, while the other is applied to a pair of unidirectional driving mechanisms that convert harmonic motion and harmonic impulses into intermittent rotary impulses in one direction. The simplest mechanism by which steady rotary motion is transformed to simple harmonic motion is a crank and a connecting-rod of suitable length. Theoretically, it is only in an infinitely long connecting-rod that a simple harmonic motion is obtained. For practical purposes, however, a length of connecting-rod of about twice the stroke is suitable. In any case, the motion can be expressed approximately by a fundamental frequency and a second harmonic of twice the frequency.

In the following analysis, for the sake of simplifying the problem, the second harmonic term will not be considered. Its influence is not very important, provided sufficient attention be given to the design of the mechanic valves and the primary and secondary couplings.

If ω is the velocity of the free end of the connecting-rod along a line passing through the axis of rotation of the primary crank, and V is the amplitude of the harmonic velocity obtained from the primary connecting-rod, and t is time, then

$$\omega = V \sin (\alpha t + \Psi) \qquad (5)$$

It will be seen that this velocity is split into two components; one applied to oscillate the pendulum or inertia weights and the other to oscillate the mechanic valves. These valves convert the harmonic forces and the harmonic angular motions applied to them into an average torque T_1 and an average angular speed α_1, so that T_1 shall be proportional to the amplitude of the harmonic forces, while α_1 shall be proportional to the amplitude of the harmonic angular motions, the harmonic force and the corresponding harmonic angular velocity being always in phase. Therefore, if F_1 = the harmonic force applied to the valves and M_1 = the amplitude of such force, then $F_1 = M_1 \sin \alpha t$, and the velocity v_1 at the point of application of this force to the valves will be $v_1 = V_1 \sin \alpha t$ in which V_1 represents the amplitude of the harmonic velocity applied to the valves. If M represents the amplitude of force at the primary, we have

$$F_1/M = v_1/V_1 = \sin \alpha t \qquad (6)$$

Assuming that no loss of energy occurs in the valves, the energy transmitted through the valves to the secondary shaft can be expressed: $F = T_1\alpha_1$, when T_1 = average torque at the secondary shaft and α_1 = average angular speed of the secondary shaft. It follows, therefore, that

$$T_1\alpha_1 = M_1V_1/2 \cos \Psi \qquad (7)$$

Since a_1 is proportional to V_1 and T_1 is proportional to M_1 we can write a_1 = a constant V_1 or, using a simple point to represent a constant, we have

$$T_1 = M_1 \cos \Psi \qquad (8)$$

It will be found, therefore, that the nearer the angle Ψ approaches zero, the higher the torque T_1 becomes for the same amplitude M_1 of force applied to the valve. (See Fig. 2.) Hence, if we assume that the valves are made so as to satisfy this condition and that the angle Ψ is practically zero, we have $T_1 = M_1$.

Application to a Motor-Car

It is evident that a converter of this ability can be applied to many uses in commercial mechanisms, but that in which we are most interested is its application to the automobile. The Constantinesco car exhibited in Paris and London for the first time late in 1926 embodies a converter such as described and the primary power is

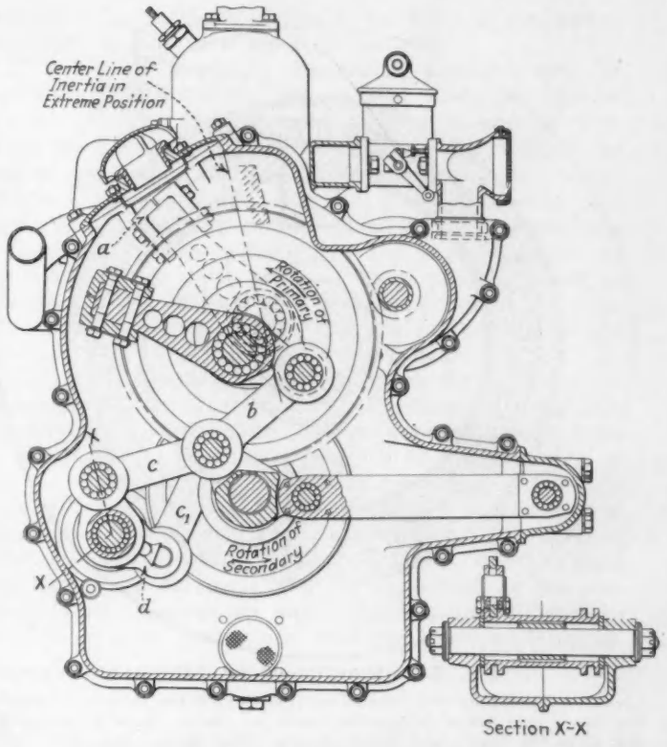


Fig. 4—Torque-Converter in Transverse Section

This Is the Construction as Embodied in the Constantinesco 5-Hp. Car. The Transmission Is Disposed between the Two Engine Cylinders, and the Engine Crankshaft Is the Primary Shaft of the Torque-Converter. Its Rotary Motion Is Transmitted to Inertia Weight *a* and Is Converted into Reciprocating Motion by the Short Arm of the Inertia Lever. Connecting-Link *b* then Transmits the Impulses through Rods *c* and c_1 to the "Mechanic Valve," or Roller Clutch d_1 Which Reconverts Them into Rotary Motion To Drive the Secondary Shaft

supplied by a small two-cylinder two-stroke-cycle internal-combustion engine having a bore of 67 mm. (2.63 in.) and a stroke of 70 mm. (2.75 in.), which give a swept volume of 493 cc. (30 cu. in.). The Royal Automobile Club rating is 5.58 hp. The cylinders are water-cooled and spaced rather widely apart, as between them are located the inertia weights and the flywheel of the torque-converter, as shown in Fig. 3. The engine cranks are placed one at either extreme end of the crankshaft proper and are set at 180 deg. to each other. The crankshaft carries two inner cranks for the two inertia weights, which are also set at 180 deg. but directly opposed in angular relation to the adjacent engine-cranks. Below the engine shaft is a secondary shaft to which torque is transmitted. This shaft carries rigidly fixed to it, the outer members of the mechanical valves, as shown also in Fig. 4.

The valves have inner and outer rings between which are two sets of segmental wedges, as shown in Fig. 5, that grip and release the rollers. The wedges normally are held in engagement by springs which restore them to their normal position at the end of each free stroke. Under pressure of the drive, relative circumferential movements of the segments occur and the grip is secured. Considering the car in process of being started on a level road, with the engine idling, the starting resistance will be moderately high. All that is happening is that the inertia mass is oscillating and has its maximum angular movement roughly about a fulcrum joining the

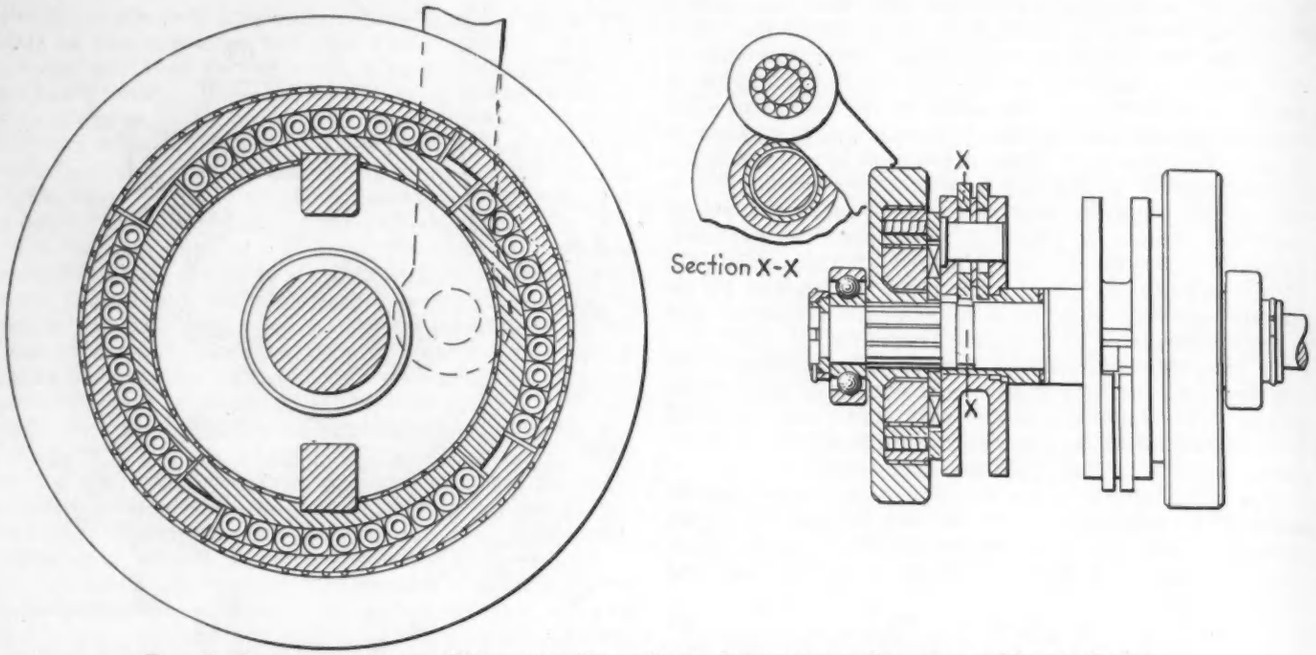


FIG. 5—CONSTRUCTION OF "MECHANIC VALVE," OR IRREVERSIBLE ROLLER-AND-WEDGE CLUTCH

(Left) A Thrust by the Connecting-Rod Causes the Rollers between the Outer and Inner Wedge-Segments to Force Them to Expand and Grip the Outer and Inner Rings. This Action Transfers the Impulses through the Segments to the Outer Enclosing Ring and to the Shaft to Which It is Splined. (Right) Longitudinal Cross-Section through the Valve, or Clutch and, above, Transverse Detail of Connecting-Rod and Its Attachment to the Inner Ring, Which Is Keyed to the Inner Segments

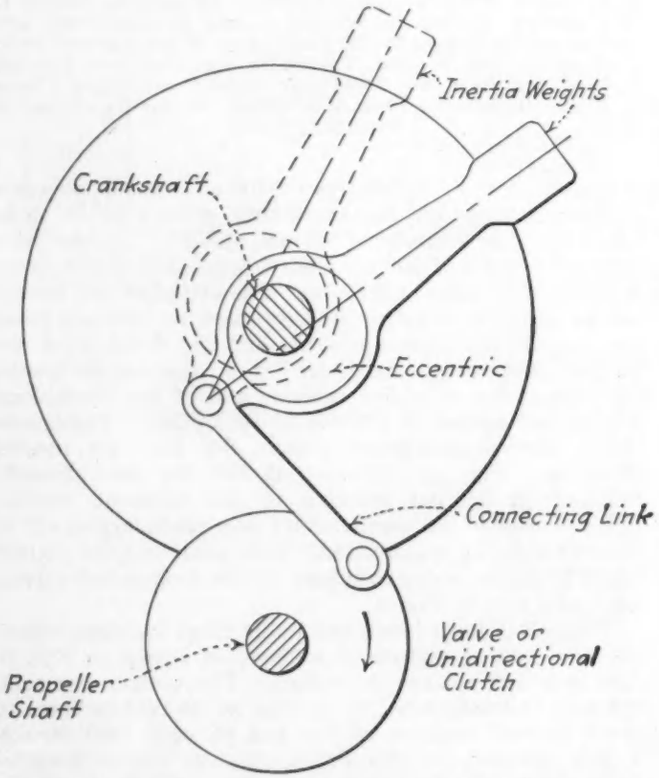


FIG. 6—ARRANGEMENT OF INERTIA WEIGHTS AND "MECHANIC VALVE" ON PRIMARY AND SECONDARY SHAFTS

With the Engine Idling, the Inertia Weights Oscillate and No Torque Is Transmitted to the Secondary Shaft. The Short End of the Weight Lever Has No Movement and No Impulses Are Communicated to the "Mechanic Valve," or Irreversible Clutch

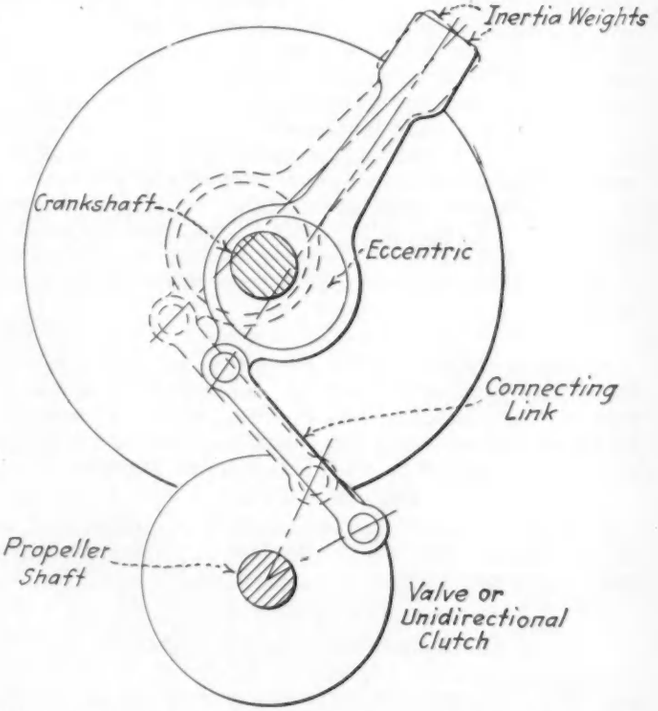


FIG. 7—ACTION OF THE MECHANISM AT FULL SPEED OF ENGINE AND CAR

The Inertia Weights Are at Rest and the Short-End of the Lever Is Oscillating. This Movement Gives Alternating Impulses to the Valve and Transmits the Torque to the Secondary Shaft

inertia to the connecting-rod of the valve, as in Fig. 6. This fulcrum, or pin, however, does not move in the direction required to rotate the valves. On opening the throttle, the engine accelerates and the inertia mass oscillates faster but has the same angular motion as

before. Oscillating an inertia element at any frequency merely calls for a fluctuating effort, positive to accelerate it, and negative to decelerate it. This effort produces a reaction at the connecting-link, as in Fig. 7, that gives a push on each valve. This push increases rapidly, in proportion to the square of the engine-speed and the amplitude of the inertia element, until it is sufficient to overcome the resistance and to start the driven shaft rotating, which sets the car in motion.

Action When Starting and Climbing

When the secondary shaft begins to move, the connecting-link end of the inertia element is oscillating along its axis; and the greater the stroke of this end of the inertia element is, the less is the amplitude of the weighted, or mass, end. As the weight is consequently oscillating at a smaller amplitude, the push on the valve, and therefore the driving torque, is decreased. At the same time, useful work is being done in overcoming the resistance of the car, and the engine revolutions no longer increase. So long as the accelerator is kept hard down, this process continues, with the car gathering speed, the connecting-link end of the inertia weight increasing its amplitude, and the amplitude of the weighted end diminishing to virtually zero, like the ball on the pendulum during rapid motion of the hand or resistance. This corresponds to a top-gear position.

If a hill of gradually increasing gradient now be encountered and the throttle be kept open, the reverse process obtains; the car speed decreases, and at first, while the inertia weight is still oscillating very little, the engine revolutions decrease nearly in proportion. As the gradient increases and the car speed decreases still further, the weight moves through an increasingly greater arc. The reduction of the engine revolutions gradually ceases until, at a car speed predetermined by design, the revolutions start increasing again, the driving ratio becoming greater and the oscillations of the inertia weight approaching their maximum.

This condition obtains with full-open throttle; but one is accustomed, of course, to using the throttle to regulate the speed. The equivalent top-gear position gives a ratio of about 5 to 1, which is a function of the converter, as the rear-axle has a 1-to-1 driving bevel-gear. The axle consists of a one-piece live-shaft carried in bearings at the spring seats. No differential is fitted. The drive is conveyed only to the near-side road-wheel, which is fixed rigidly to the driving-axle. In the center of the axle shaft two bevel-gears are mounted freely on ball-bearings with their teeth facing and with the driving-pinion be-

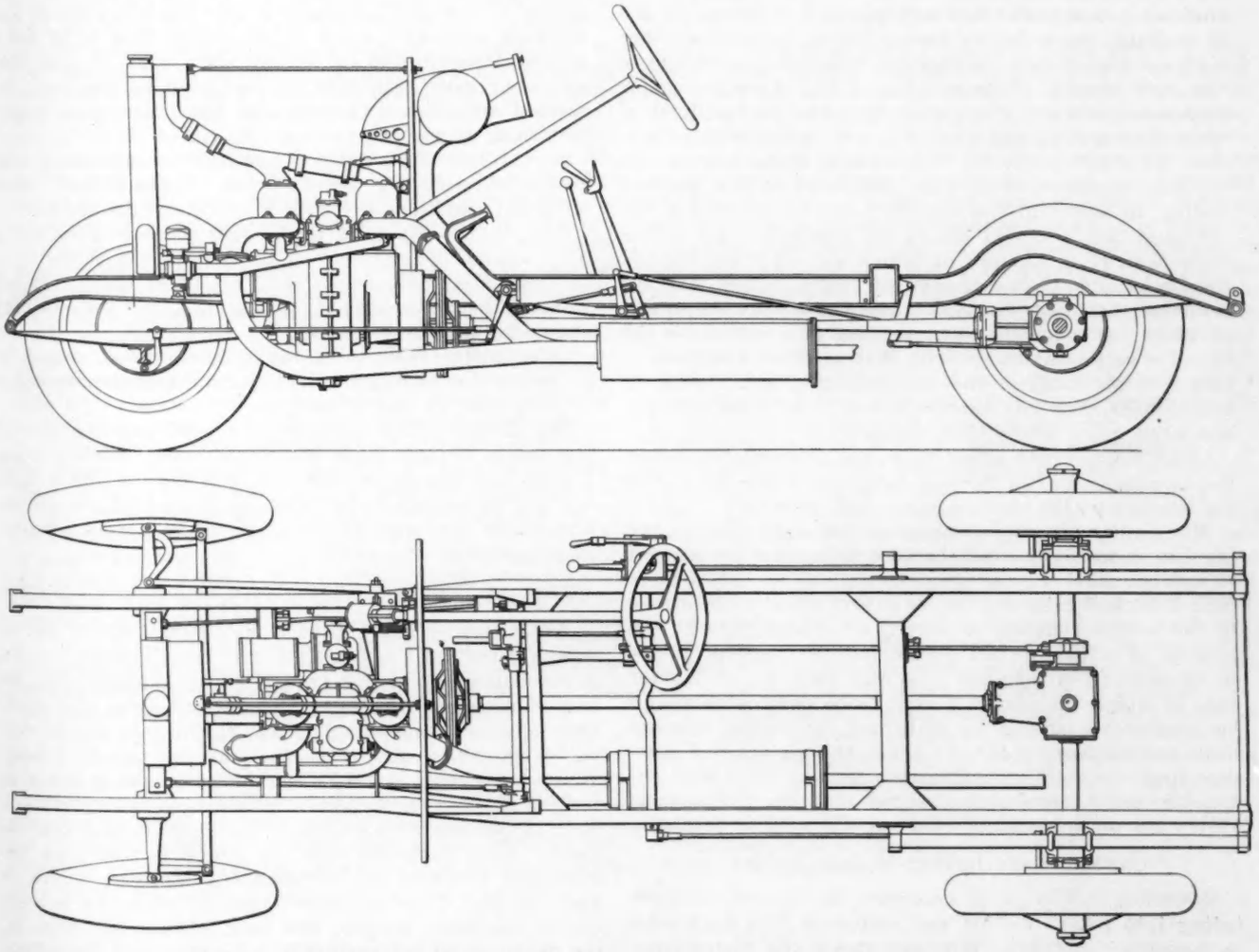


Fig. 8—Elevation and Plan of Car Fitted with Constantinesco Torque-Converter

This Has a 5-Hp. Two-Cylinder Two-Cycle Engine in Which the Torque-Converter Is Placed between the Cylinders, and the Engine Crankshaft Is the Primary Shaft of the Transmission. The Secondary Shaft Is Below and Drives the Flywheel. No Clutch Is Provided. Drive Is through a Flexible Connection between the Flywheel and the Propeller Shaft. Reverse Motion Is Obtained at the Rear Axle by Sliding the Gear Casing Laterally To Disengage a Forward-Drive Bevel-Gear and Engage a Reverse Gear

tween them and engaging with both. Between the bevel-gears, and solid with the axle shaft, is a double dog by means of which either bevel-gear may be engaged with the axle shaft. Engagement is made by moving the complete bevel-gear casing along the axle shaft. This shaft is arranged so that on forward speeds the propeller-shaft is in line, the condition for reverse motion being less important.

The weight of the car, whose complete layout is shown in Fig. 8, is about 1792 lb. When driving this car in London, I gained the impression that it would have performed better with a more powerful engine, as the acceleration from rest after a traffic stop was very slow. Very high engine-speed was required to bring the car to normal speed, and this was most disturbing. However, the torque-converter functioned perfectly, and the car was so simple to control that I am disposed to believe our engineers should consider this type of transmission.

THE DISCUSSION

A MEMBER:—About 18 months ago I had an opportunity of driving in London two of Mr. Constantinesco's first experimental cars. If one could have his own opinion as to the reaction of the driver of a vehicle equipped with one of these torque-converters, it would be that the driver should be chary of overcriticizing a gear of this nature, which is a new application of an old theory to practical engineering.

M. C. CHANDLER[2]:—The comparison of this drive to an electric drive is a good one. In the steam car considerable energy or power is stored in the boiler. In the gasoline car of conventional change-gear type, immediately before letting the clutch in, we impart some of the engine's power to the flywheel, where it is stored-up and is available, upon letting the clutch in, to apply at once a rather high torque through the transmission system to the road wheels. With a drive of the character under discussion, however, the power imparted to the flywheel when accelerating the engine is not immediately available for starting the car. The same holds true of the old Entz system, and the fact mentioned by Mr. Jack of having to speed-up the engine inordinately to get the car in motion also was one of the characteristics of the Entz system, in the use of which some drivers applied the brake and when a change of traffic signals was anticipated increased the engine speed to secure the multiplication in torque that was necessary to accelerate the car at a rate comparable with that of other vehicles. It seems to me that, in the application of this device to automobiles, this characteristic would be disadvantageous when quick starts were required.

QUESTION:—What effect does the converter have on the pressures on the flywheel bearings when the car is stationary and the throttle is opened suddenly?

MR. JACK:—In such conditions the load due to the inertias is not very great because these inertias are set in balance, that is, the weights are set at 180 deg. to each other and their oscillation is very small. The stroke of the inertia elements is very short compared with the lengths of stroke we are accustomed to consider in internal-combustion engines. It may be that in heavier cars in which the inertia forces to be dealt with would be greater we should be disturbed by excess bearing loads and unbalanced forces; but in the car which I have described virtually no vibrations of any kind are noticeable and I have been assured that the torque-converter has no detrimental effect on the engine bearings.

CANNOT VARY ROTARY-MOTION TORQUE

QUESTION:—Why is it necessary to convert reciprocating into rotary motion and reconvert this back into reciprocating motion? Why not attach the piston connecting-rod directly to the inertia element?

MR. JACK:—The only way in which a variable can be obtained between the rotating primary and secondary shafts is by transforming the motion out of the rotary phase. No means exists whereby the torque can be graduated except to transform the motion into a vibratory or oscillatory phase and out of a direct-operating rotary motion. The prime movers we use today convert reciprocating into rotary motion, which is an available product. The real problem is the transmission of this from the engine to the rear axle, and Mr. Constantinesco has endeavored to provide a mechanism which will transmit a torque that varies with the resistance at the rear wheels. The only way in which this can be done, if the primary torque is virtually constant, is to provide some means of varying the speed of the secondary shaft, and the only method I know of for doing this is to use a geared transmission or set up some sort of pendulum action or some vibratory process such as has been described and then transform the oscillations into rotary motion by means of ratchets.

QUESTION:—How efficient is this transmission system compared with the conventional transmission? How quiet is it, and how well does it withstand the service?

MR. JACK:—By tests made with the converter and a 5-hp. engine the efficiency of the system was found to be approximately 80 per cent for 1 hp. transmitted. It will be seen, therefore, that at full engine power the efficiency should be very high.

QUESTION:—What size mechanical valves would be necessary for an engine developing the horsepower that is acceptable in this Country?

MR. JACK:—It is necessary to work out the size of the valves to suit each individual case. Mr. Constantinesco has passed on only the information for a light car as I have given it, but it seems to me that the adaptation of the converter to a heavier car is merely a matter of proportion.

VIBRATORY TENDENCY ELIMINATED IN AMERICAN PATENT

A MEMBER:—The United States Patent Office has issued a patent on a device similar to Mr. Constantinesco's. A mechanical valve for transforming impulses into rotary motion and the same inertia principles are used; that is, alternating impulses are rectified by mechanical valves in which all of the motions are purely rotary. When the device is in phase, the entire mechanism as well as the inertia weights has a simple rotary motion. It is of interest to know that this problem has been attacked in a different way in America and that the vibratory tendency of reciprocating motions, which is used in Mr. Constantinesco's transmission to balance piston vibrating weight, has been eliminated; that is, the device itself is constantly in balance and the vibratory tendencies are equally possible under all conditions. I do not know the name of the inventor or that any development work has been done on his invention. Un-

[2] Research engineer, Marvel Carbureter Co., Flint, Mich.

doubtedly, from a mathematical standpoint, this system is the most perfect power-transmission mechanism conceivable.

I think the term "torque-converter" is a happy one, but the device actually converts motion into torque. If we conceive the driven shaft to be held stationary by a resistance greater than the peak of the driving impulse, the driving-engine shaft rotates without load or dissipation of energy provided friction can be eliminated from the device itself. Under these conditions, motion is unopposed by force.

As Mr. Jack has pointed out, the peak of the driving impulse varies as the square of the engine-speed. When the peak impulse is high enough to move the driven shaft, we have torque plus motion in the driven shaft. The product of this torque plus the regular rotation will always equal the product of the torque taken from the engine multiplied by its rate of rotation. In other words, if an engine is running at 1000 r.p.m. and is developing a certain torque, and the driven shaft is turning at 100 r.p.m. and absorbing power, we know that the torque absorbs 10 times the amount of power delivered.

The mechanism differs from the electrical system, in which the prime mover takes the form of the storage battery, which produces static torque without motion but only at the expenditure of energy. With the torque-converter, by motion unopposed, static torque is produced without the expenditure of any energy. It is in that sense directly superior to any other power-transmitting mechanism of which I know, because the tendency to move requires the expenditure of no energy whatever.

Highway Accident Prevention

CAUSES of motor-vehicle accidents, in Connecticut at least, are now well understood. There is a premise which, with a conclusion drawn from it, should go with and qualify the subject as a whole. It will be found by students that, while it is true that every motor-vehicle accident has a cause to which it is popularly ascribed, such, for example, as inattention, failure to grant a right of way, skidding, or poor machinery, or something of that kind, yet in almost every instance that is a proximate cause only and no accident would have happened unless preceding it there had been a mental failure or slip. In other words, almost every motor-vehicle accident has in its background and as its fundamental cause a failure of mind action. To put it even more plainly, the lack of mental agility, mental reaction to conditions, or of nerve force to meet an unusual traffic situation suddenly presented, is the fundamental reason for nearly every motor-vehicle accident. A program, to be sensible, must recognize this and be directed mainly, not at the proximate cause, but at the fundamental cause.

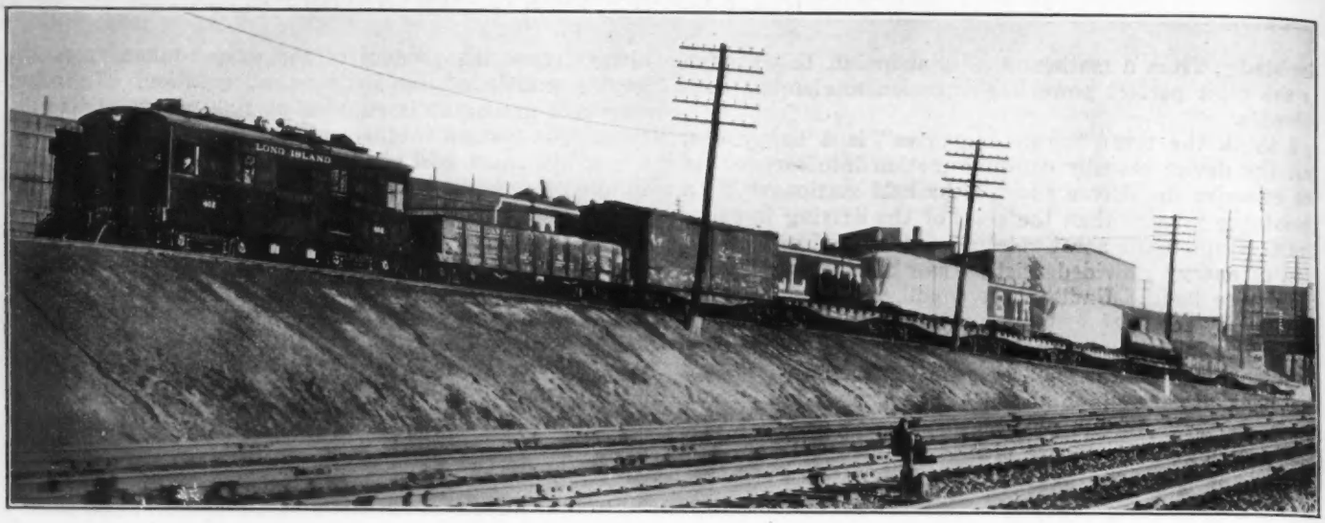
All highway and street builders must give more careful study to the actual environment from the viewpoint of safety, always conscious that they need to consider the mind attitude of the operator of a motor-vehicle or of the pedestrian or other participant in traffic. The road builder or engineer must put himself into the driver's seat of every car and into the position of every pedestrian and see what, if anything, there is which he, by his particular scientific knowledge, can correct or change so that the traffic participant will be relieved of a problem. In Connecticut, the State Highway Department has been employing this type of safety engineering for several years and it is now so thoroughly effective that accidents on the highways of the State are gradually becoming less. By the installation of signs, clearing the sight lines at intersections, straightening bad curves, building fences, indicating center lines, and by numerous other devices, these highways have been so cleared and are now so good that fewer drivers and pedestrians are being caught.

It is an axiom that serious accidents do not often happen in obviously dangerous places, but almost invariably occur in places which look safe. Within a short time, when experience with four-track roads has been acquired, there will be only the ordinary percentage of accidents, but until that experience is acquired we may expect to hear of other accidents in numbers larger in proportion than on similar highways of less width. The pedestrian on the four-track road is invariably inclined to walk too near the center. A chief reason for trouble is that everyone gains the impression of space and safety.

Scientific-Study Basis

There ought to be careful scientific study and a written record made by each engineer or authority in charge of every location where traffic accidents occur. It should be made the duty of the traffic supervisor in every municipality to see that this is done. If an authority issues traffic regulations he should be sure that they are reasonable and he should thereafter demand exact compliance. Enforcement has been too much a matter of allowances. That is one reason for a large number of minor accidents. For example, it may not make a great deal of difference whether a man is driving a car 20 or 25 m.p.h. so far as actual control of the car is concerned, but from the viewpoint of discipline, if an authority has reasonably determined that the lower speed is proper, then everybody ought to be held to it. Speed, even sometimes comparatively slow speed, is a factor in most accidents because, if the speed, even though slow, is yet too great for conditions, then the car is out of control for the normal mental action of the average operator.

No person is safe in traffic, either as a pedestrian or as an operator, who is not concentrating on traffic participation and is not alert to see whether everybody else in traffic with him is also on the job, or whether some one is about to create an emergency which he must be prepared to meet. A program for traffic betterment practically amounts to getting everybody to take care and exercise his rights more conservatively, and to demand more conservatism from others. In no other way will the situation ever become very much better. Civic authorities everywhere must be required to make a careful scientific study as to whether the highways and streets are in any detail contributing to accidents. Enforcement authorities must demand more perfect obedience. This means obedience to signs, obedience to traffic lights, obedience to the officer, and to every possible detail of preventive police work. The State and all of the volunteer organizations that can be enlisted to help must attempt education in an even greater degree than heretofore.—Commissioner R. B. Stoeckel, Department of Motor Vehicles, State of Connecticut.



BRILL-WESTINGHOUSE GASOLINE-ELECTRIC SWITCHER ON A 4-PER CENT GRADE

Internal-Combustion Engines in Rail Transportation

By A. H. CANDEE[1]

PENNSYLVANIA SECTION PAPER *Illustrated with* PHOTOGRAPHS

UTILIZATION of internal-combustion engines for transportation over rails is merely the application to practice of basic economic principles. If we analyze the factors contributing to our present civilization and prosperity, it will be found that the adoption of efficient machines or tools to save human labor has been responsible in a large measure for this condition. Another factor is the efficient use of our natural resources. Further, a large measure of our present prosperity may be attributed to the division between labor and capital of the savings in labor effected through their cooperation.

When machines and tools are spoken of it is natural to think of factories and machine-shops, but railroads also are manufacturers. Their product is ton-miles and passenger-miles. The measure of the effectiveness of the railroads as manufacturers is the sale price of their products compared with the cost of production, and they should therefore be interested in any tool that will increase the differential between cost of produce and price received. As a matter of fact, the individuals comprising the organization should be especially interested in this increase because it is an economic fact that as a class their purchasing power can be increased only by greater production for any given amount of labor.

The railroads of this Country have reached their tremendous proportions only by the use of that effective, reliable and spectacular tool, the steam locomotive. Were the steam locomotive less reliable and versatile than it is, the growth of our Nation would have been stunted and the West might still be wild and woolly. It is with a sense of pride and respect that we refer to our railroads as "steam" roads.

[1] Railway engineer, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Were the steam locomotive less reliable and versatile than it is, the growth of our Nation would have been stunted and the West might still be wild and woolly. It is with a sense of pride and respect that we refer to our railroads as "steam" roads.

The interest taken by the railroads in propulsion by means of the internal-combustion engine is exceedingly encouraging to those who advocate this motive power.

Gasoline and Diesel engines have already been applied in numbers for rail-propulsion duty and have proved reliable and practical for rail-car service at least.

There are between 450 and 500 gasoline-driven rail-cars now in operation in this Country.

The locomotive field holds greater promise for the manufacturer than does the rail-car, because there is a possible demand for only about 3500 to 5000 rail-cars, and there are 75,000 steam locomotives that might be replaced.

Savings effected by rail-car operation are due to saving in crew expense, saving in fuel, reduction in maintenance and attendant charges, and imporved availability.

The preferred form of the locomotive oil-engine has not yet been defined.

The electrical form of transmission embodies qualities that render it the most practical for propulsion on rails, especially with engines larger than 125 hp.

We find that rail-cars of 250 hp. are called upon for services formerly performed by steam locomotives of 800 to 1000 hp. capacity, and often they can do them surprisingly well.

The present-day steam locomotive is the result of 100 years of development, much of the detail refinement having occurred within the last decade. The future holds promise of further improvement by the use of higher steam-pressures, steam turbines and condensers. Any new form of motive power enters the field under a very severe handicap and must be tried and proved thoroughly before it will be given serious consideration by the steam roads, hence the interest taken by the railroads in propulsion by means of the internal-combustion engine is exceedingly encouraging to those who advocate this motive power.

Electrification Not Universally Available

The steam locomotive has lost the race for supremacy in some classes of service. I refer to the electrification of railroads such as the New York, New Haven & Hartford; the Norfolk & Western; the Virginian; the Pennsylvania; the Chicago, Milwaukee & St. Paul; the Long Island, and others. Here the operating economies and advantages have been proved beyond doubt. There are many other places in the Country where electrification will do as much and show equal operating advantages, but for the great part of the present steam-operated mileage the steam locomotive cannot yet be displaced.

It has been within our lifetime that the tremendous possibilities of liquid fuels have been realized. Application of the internal-combustion engine to millions of highway vehicles, to ships, and to stationary service has proved it to be a thoroughly effective and reliable tool. Yet considerable development and research work will be necessary before it can be adopted generally to replace steam locomotives. We are beginning to learn how to build light-weight high-speed engines, but there is still a great deal to learn.

Gasoline and Diesel engines have already been applied in numbers for rail-propulsion duty and have proved reliable and practical for rail-car service at least. The Patton Motor Car Co. built a car in 1890, powered with a small gasoline engine with electrical transmission. A gasoline rail-car with mechanical transmission was built in Wurttemberg, Germany, in 1893, and a similar model was operated in Chicago in 1899. Extensive development in the motor rail-car field began in 1900 and 1901, led by the French Westinghouse Co. During that time the McKeen car, the Strang car and the General Electric car first appeared. In 1902 the first extensive application of gasoline-driven cars was made by the French Westinghouse to the Arad-Csanad lines in Hungary, and the number of cars was increased from time to time until approximately 70 were in operation in 1912. The latest reports indicate that about 50 of these are still in serviceable condition.

The McKeen car, with its mechanical transmission, has survived, and numbers of them are in operation still. The Strang car fell by the wayside, probably because it was somewhat complicated by the use of a storage battery as a supplementary source of power. The General Electric car survived, and approximately 88 of these were built. From available reports it is estimated that about 70 of these are still in use. Due to war activities, gasoline-car development slowed down and stopped from 1914 to 1920.

Improved Engines Meet Post-War Needs

Prior to the war the chief obstacle to unqualified success was engine design, but the war brought about marked advance in this. Because of increased operating costs, the railroads reopened the question of gasoline rail-cars in 1920, and a number of light-weight units were constructed. The first of these were simply highway trucks with flanged instead of rubber-tired wheels. These modified trucks were light in weight and construction. Several modifications and improvements followed, but the experience indicated the need of more power and heavier car construction. It also showed that very definite economies were effected.

The next major step was the construction of the Brill Model-55 car. This conformed more closely to the ideas of the railroad men and was found to be thoroughly practical for light branch-line service. A very satisfactory form of mechanical drive had been worked out and this contributed materially to the success of the car.

A number of small cars sprang up almost overnight, but the demand for small cars had passed the zenith because the railroads demanded more power and trailer-hauling capacity. Next the J. G. Brill Co. brought out its Models 65 and 75 with horsepower as high as 190, and the Sykes mechanical-drive car appeared with its 175-hp. engine. The Electromotive Co. then applied electrical transmission to a 175-hp. engine, and a Brill car appeared with a 250-hp. engine with electrical transmission similar to that shown in Fig. 1. All of these cars proved reliable when properly applied.

There are between 450 and 500 gasoline-driven rail-cars now in operation in this Country. The electrical form of transmission has been selected for a large majority of all cars bought within the last 2 years.

Diesel engines appeared on rail-cars in Sweden about 1913. Their use has not spread rapidly in Europe, so there probably are not more than 25 or 30 cars now operating there with Diesel engines. On this continent the first oil-engined cars appeared in 1925, when the Canadian National Railways built two, one of which is shown in Fig. 2, powered with a Beardmore eight-cylinder solid-injection oil-engine of 400-hp. capacity. This engine, which is shown in Fig. 3, is a modification of the Beardmore aircraft oil-engine. The first two cars

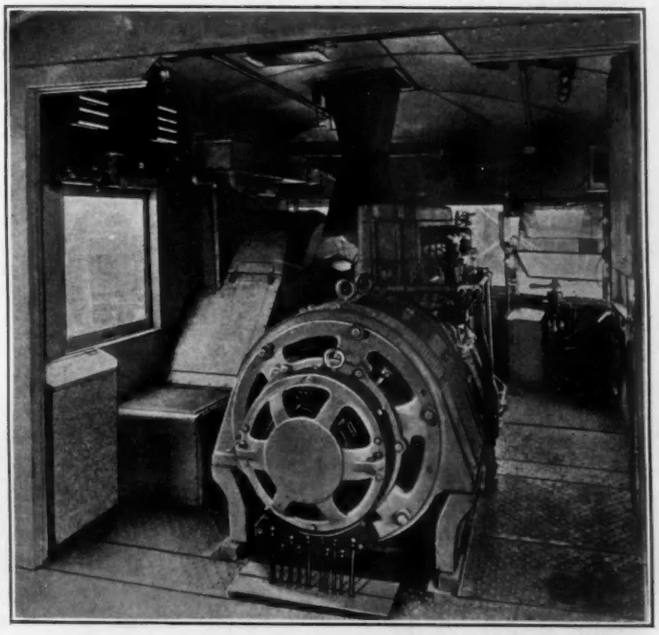


Fig. 1—Engine-Room of Brill 250-Hp. Car

The Brill-Westinghouse Powerplant Is in the Foreground, and the Engineer's Controls Are Seen at the Right in the Background. Two Similar Powerplants Are Used in the 500-Hp. Rail-Car

were followed by seven more, each powered with a 200-hp. four-cylinder engine. The success of these units has been such that an order has been placed recently with the Beardmore Co. for five engines of six-cylinder design and 300-hp. capacity.

Small Oil-Engined Locomotives Are Successful

Numerous attempts have been made to produce oil-engined locomotives during the last 7 years, but only in the smaller sizes have they met with any degree of success. In these sizes, however, they have proved the economy of this type of motive power. A 1000-hp. Baldwin-Westinghouse locomotive is shown in Fig. 4, and numerous large old-powered locomotives are now proposed or under construction. The next 2 or 3 years will see some long strides taken. The locomotive field holds greater promise for the manufacturer than does the rail-car, because there is a possible demand for only about 3500 to 5000 rail-cars, and there are 75,000 steam locomotives that might be replaced.

In considering the economics of the situation, we have reliable operating-cost data on rail-cars only. Whereas steam-train costs on branch lines vary from $0.75 to $1.50 per train-mile, with an average of from $0.90 to $1.00, we find that the service can be handled by gasoline engines at a train-mile cost varying between $0.30 to $0.60 with an average approximating $0.36 to $0.40, including fixed charges. Oil-engine-driven trains will operate at a cost between $0.25 and $0.50 per train-mile, with an average of $0.33 to $0.35, also including fixed charges. In addition, there are a number of indirect returns that are exceedingly difficult to evaluate; among them being reduced right-of-way maintenance, reduced attendant facilities and charges, and improved public relations.

Savings effected by rail-car operation are due to saving in crew expense, saving in fuel, reduction of maintenance and attendant charges, and improved availability. The first of these goes back to the economic principle of greater production per man. The original light-weight rail-car often saved its price within the first year, and the modern cars usually require less than two years to do the same.

The thermal efficiency of the steam locomotive is admittedly low, averaging not more than 6 per cent at the rail. Without an abundant coal-supply we would have been forced to reduce this loss long ago, but in spite of the apparently unlimited supply of this fuel we are handicapping posterity by this tremendous waste. France and other European countries are turning to electrification on account of coal costs. How long can we expect to feed our 70,000,000 steam-locomotive horsepower at a cost of $1 in fuel for each 6 cents' worth of actual work?

More Efficient than Steam Engines

The thermal efficiency of the gasoline-engine powerplant is considerably higher than that of a steam locomotive, for we can get as much as 20 per cent of the energy of the fuel at the rail. This does not mean that we can operate with gasoline at one-third of the fuel expense for a given service, because the cost per pound of gasoline is considerably higher than that of coal.

The oil-engine powerplant as applied to propulsion on rails will operate at an over-all thermal-efficiency as high as 25 per cent. In addition, the present cost of fuel oil makes possible a considerable saving in the total fuel-expense with the oil engine.

Comparing the steam locomotive with the internal-combustion locomotive as to availability for service, statistics show that the average steam passenger-locomotive operates 113 miles per day. This is the distance from Pittsburgh to Altoona, over the Pennsylvania Railroad. An average of the daily trains shows that the run takes 3¼ hr. This may be taken as the steam passenger-locomotive's available time per day, while a locomotive with an internal-combustion-engine powerplant can easily average from three to four times this service.

It generally is not feasible to apply existing standard engines to rail-propulsion service. Engines used in automotive work usually are small and lack the necessary stamina. If an engine possesses the stamina it is usually because it has been built for stationary work and it is too heavy and large for transportation purposes. It seems necessary, therefore, to design engines for this particular application. Engine speeds must be high to reduce cost and weight, yet reliability and long life are

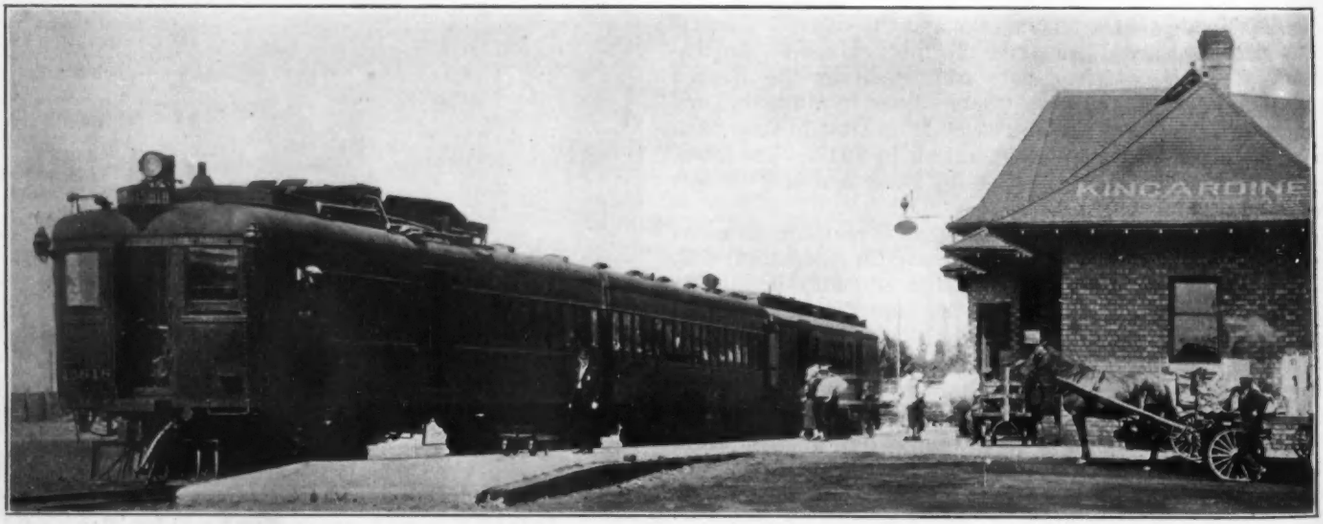


Fig. 2—Canadian National Rail-Car Train

This Train Is Powered with an Eight-Cylinder 400-Hp. Beardmore Oil-Engine with a Generator and Four Railway Motors of Westinghouse Make. Two Rail-Cars Like This Were Built in 1925 and 12 Others with Smaller Engines Have Been Put into Service Since

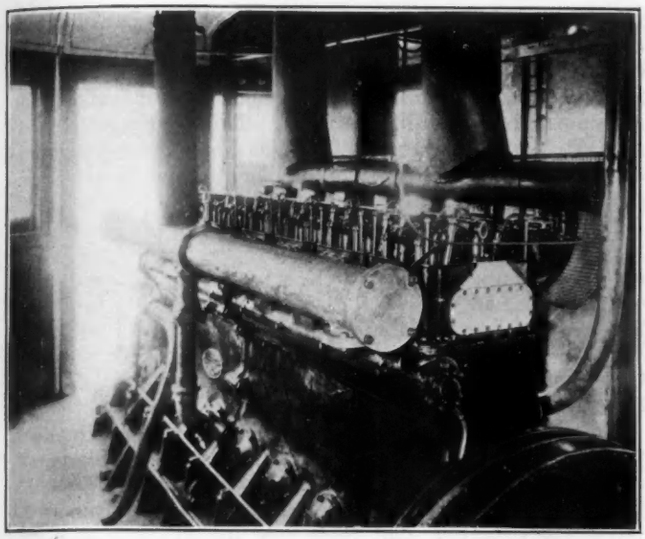


FIG. 3—EIGHT-CYLINDER 400-HP. BEARDMORE OIL-ENGINE
This Is the Engine Used in the Leading Car of the Train Shown in Fig. 2. It Uses Solid Injection and Develops 400 Hp. Later Canadian National Railways Cars Have Been Powered with Similar Engines of 200 and 300 Hp., Having Four and Six Cylinders Respectively

of paramount importance. The fact that a year of rail-car service is equivalent to 10 years' service for an automobile engine will give a conception of the duty imposed in this field.

BEST TYPE OF ENGINE UNDECIDED

In the gasoline-engine field, the knowledge needed for building suitable units is available; but as the present production is small there are few engines on the market. In the oil-engine industry, however, there has been very little accumulated experience suitable for the production of engines for propulsion on rails, in which service dimensions and weights are prime considerations. For stationary and marine purposes, oil-engine weights run from 60 lb. per hp. upward, whereas for rail-vehicle use they must be less than 45 lb., and preferably not greater than 20 lb., per hp. Slow engine-speeds are not tolerable because slow speeds mean increased weight in both engine and generator, resulting in further addition of weight for strength in car bodies or locomotive construction, thus pyramiding both weight and cost of the vehicle as a whole.

The general automotive field has been built up around the four-cycle engine, with cylinders arranged in line or in a V. Aircraft engines are following somewhat different arrangements, such as radial cylinders. The preferred form of the locomotive oil-engine has not yet been defined. While the present tendencies are toward the use of four-cycle engines, on account of available knowledge and experience, a number of very promising developments are being undertaken in the two-cycle field. In oil engines, solid fuel-injection is preferred to air injection.

MECHANICAL TRANSMISSIONS ON SMALLER CARS

The transmission of power from the engine to the wheels forms a broad subject in itself. In rail-cars, when engine sizes were small and a single rear-axle was used, the ordinary gearshift form of automotive transmission was sufficient and satisfactory. When weights increased to such an extent that it became necessary to drive through a four-wheel swivel truck, the mechanical drive became a serious problem. The Brill company accomplished this very satisfactorily by transmitting power to a set of gears in the truck bolster and driving the wheels from there, so that swiveling of the truck did not seriously affect the drive. In other cars engines have been mounted directly on the truck to obviate the drive difficulties, the gear-shifting and clutch operation being controlled electro-pneumatically in one case.

A mechanical transmission of large size is in use on the Lomonosoff locomotive in Russia. This utilizes magnetic clutches with the gears constantly in mesh. The Boston & Maine Railroad placed an order recently for one of these 1600-hp. mechanical-drive locomotives to be built in Europe, so we should soon be able to get some first-hand information as to the operation of this type of drive.

Hydraulic transmission has been tried several times with some degree of success, but at this time it does not seem to have a very large field of application in rail service.

ELECTRICAL TRANSMISSION BEST FOR LARGER UNITS

The electrical form of transmission embodies qualities that render it the most practical for propulsion on rails, especially with engines larger than 125-hp. For smaller engines there are satisfactory mechanical transmissions and the advantages of the electrical form are sacrificed for the sake of cheap construction. The essential advantages which make the electrical transmission the most desirable are the smooth flow of power to the wheels, regardless of tractive effort or speed; the flexibility of control and application of power; and the absence of rigid or troublesome mechanical connections between the spring-mounted engine and the wheels.

Present limitations in the application of engine-driven vehicles to rail service are imposed by the size of engine that can be applied to the vehicle. We would like to apply engines of two or three times the horsepower capacity now used, but this is not economically possible on account of weight and cost. It is therefore essential that the utmost use be made of the engine which may be applied. The electrical transmission permits such utilization over a very wide range. Curves show that a 1250-hp. locomotive with electrical transmission has better performance throughout than has a 1600-hp. locomo-

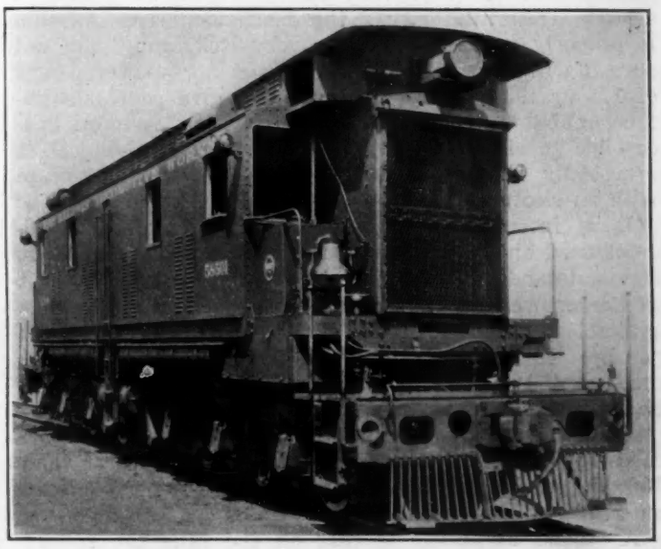


FIG. 4—1000-HP. BALDWIN-WESTINGHOUSE OIL-ELECTRIC LOCOMOTIVE

tive with mechanical transmission, even though the losses in the mechanical transmission are claimed to be lower than those in the electrical drive.

To the mechanical man the electrical transmission may seem complicated and mysterious, but as a matter of fact it is simple. The engine is coupled directly to a simple generator which furnishes power to propulsion motors geared to the axles. An auxiliary generator, also driven by the engine, furnishes power for exciting the field of the main generator and also for charging a small storage-battery used for engine starting and car lighting. The control of power also is simple. With gasoline engines this usually is accomplished by merely varying the engine-speed, automatic adjustment of the current and voltage being built into the apparatus. With the oil engine, which has a narrower range of speed control, it is sometimes necessary to make some generator-field adjustments before raising the engine-speed, but these involve very little complication and are made automatically with movement of the throttle-control lever.

There are numerous variations of these schemes of control and they demonstrate the extreme flexibility of the system. However, electrical designers realize the importance to the railroads of electrical simplicity and are directing their efforts toward that end.

Auxiliaries Are a Troublesome Problem

In the electrical system of power transmission, as in any other system, the problem of auxiliaries is troublesome. Compressed air must be provided for the brakes, and cooling air for the radiators. Batteries must be charged, and in some cases heat and light must be provided for trailing cars. It is these auxiliaries that cause a large part of the apparent complication in the self-propelled vehicle; yet they must be provided for, whatever system of transmission is employed.

In the application of engined cars or locomotives to rail service we find that rail-cars of 250-hp. are called upon for services formerly performed by steam locomotives of 800 to 1000-hp. capacity, and often they can do them surprisingly well. It is also found that in a great many cases the railroads call for cars that can reach a balancing speed considerably higher than that required for any normal branch-line service. The psychological effect of being able to attain a 60-m.p.h. speed is wonderful, but on the other hand such speed imposes restrictions on the trailer capacity.

In the electrification project the service duty imposed upon the electrical equipment can be calculated accurately and adhered to. In the case of the internal-combustion-engined vehicle, though, it is necessary to design for general service and a wide variety of conditions such as may confront steam locomotives. This means that equipment size is often greater than that required for specific applications.

No reference has been made to the internal-combustion engine as applied to highway vehicles in railroad service. It is well recognized that both the motorcoach and the motor-truck are now very important adjuncts to rail transportation, and their use undoubtedly will expand considerably. After all, the real business of the railroads is transportation, whether by rail, by water, or by highway, and through proper coordination of transportation systems the best interests of the Nation will be served.

To review briefly the motive-power situation as it seems to be developing, the steam locomotive is not seriously threatened in the near future, but its ultimate position depends upon the rate of progress its designers can provide. In a number of places it will be supplanted by electrification, because, in some cases, the latter can show economies of operation which cannot be attained by steam or by internal combustion. In the near future the internal-combustion engine undoubtedly will supplant steam on light-traffic lines, in yard switching-service, and where fuel and water are hard to obtain. Beyond that, development and service will govern its expansion in the locomotive field.

THE DISCUSSION

Chairman C. O. Guernsey:[2]—I do not agree with Mr. Candee when he says that 125-hp. is the minimum in electric transmission. If the mechanical transmission is properly operated it works very well, and I am not sure it will not do so with very great horsepower. Cars of 175 or 190-hp., properly operated, give perfect satisfaction, but the mechanical transmission is more susceptible to abuse than the electric transmission. It is practically impossible for the operator to do damage with an electric transmission.

It is interesting to compare the automotive equipment used on the rails with that used on the highways. One outstanding difference is in the ratio of weight to horsepower. An ordinary five-passenger sedan has available some 60-hp. with about 60 or 70 lb. weight per hp. In rail operation it is good practice to use as much as 450 or 500 lb. per hp., giving ability to meet any train schedule. The average steam-train speed can be made with weights up to 900 lb. per hp., and in some cases equipment is operating with weights greater than 1000 lb. per hp. Naturally, that affects the performance on grades.

A second difference is that on the rails the rolling resistance per ton is very low, ranging from about 5 to 20 lb. per ton at various speeds up to 60-m.p.h., compared with a resistance of about 40 lb. per ton at moderate speed on a good macadam road.

Mr. Candee touched upon a third difference, that of relative life. Engines of rail equipment are expected to run farther before the carbon is cleaned out than the usual automobile runs in its entire life.

The fourth difference is that, because of low rolling-resistance, the ton-miles per gallon of fuel are very high. In regular service at ordinary speed, with stops and pumping, 120 ton-miles per gallon is attained. On the Pennsylvania Railroad there are records of 250 to 255 ton-miles per gallon when the operators are careful.

Mr. Candee mentioned the saving in using oil fuel. Eventually that will be a considerable item. At present, the greater bulk and lower speed of Diesel engines, with the resulting heavier electrical units, make the power-plants heavier and more expensive than gasoline power-plants, and they require more space in the car. The result is that for runs of less than 200 miles per day the gasoline equipment is actually cheaper because of its lower depreciation and maintenance cost. It costs about $500 per foot to build a car body, so it is apparent how important it is to keep the engine-room small.

[2] M.S.A.E.—Chief engineer, automotive car division, J. G. Brill Co., Philadelphia.

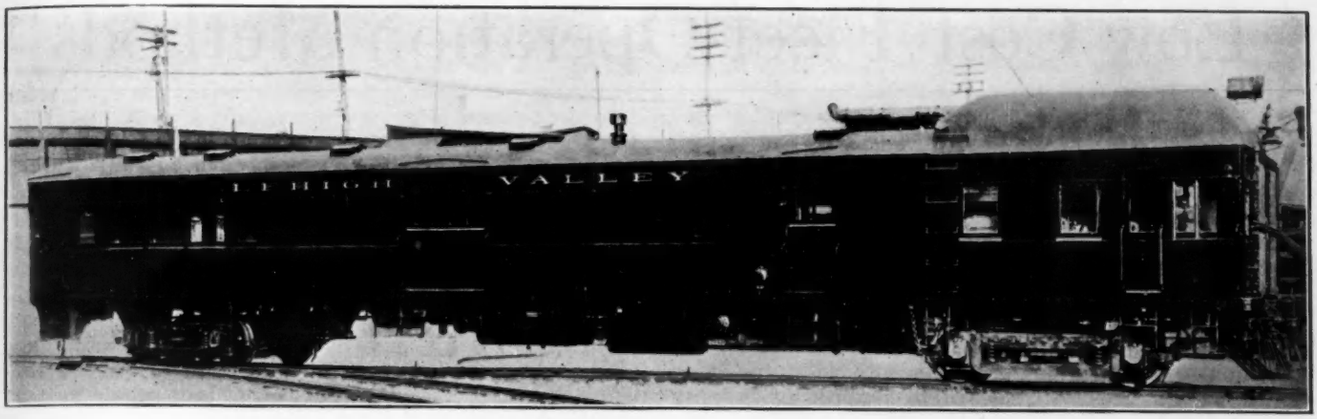


FIG. 5—500-HP. RAIL-CAR
This Car, Built for the Lehigh Valley Railroad, Is Driven by Two Brill-Westinghouse Powerplants Like That in Fig. 1

Because of the small production, the cost per horsepower of the rail engine is considerably higher than of the automobile engine. The cost is about $20 per horsepower. That is continuous horsepower and should be compared with the power of an automobile engine at the speed at which the car is run continuously.

Present gasoline engines weigh about 15 lb. per rated horsepower. The smallest Brill car, Model 55, weighs 30,000 lb. and has 70-hp. The 55-ft. Model 75 weighs 55,000 lb. The gas-electric 250-hp. car, 60 ft. long, weighs in the neighborhood of 90,000 lb. That same car built 75 ft. long weighs from 73,000 to 110,000 lb., and the double-powerplant car, shown in Figs. 5 and 6, weighs 130,000 lb.

ANTIFRICTION BEARINGS REDUCE POWER NEEDS

W. C. SANDERS[3]:—Because of the greater weight per horsepower of the self-propelled rail-car, reduction of starting resistance is more important than in an automobile. It is essential to have available all the power possible to accelerate the car. There has been some skepticism as to the ability of antifriction bearings to withstand the service imposed upon them in rail-cars, particularly at the journal bearings. However, they have demonstrated their durability in actual service and are now in use widely. Their service on these cars has been the entering wedge for their adoption on heavier railroad equipment.

Antifriction journal bearings make a distinct power saving in comparison with plain bearings. Recent tests secured during actual runs of over 200 miles per day show this saving to be about 10 per cent, on a gross ton-mile basis. In these tests graphical records of the current and voltage in the motor circuit were obtained, checked at intervals by readings from an indicating ammeter and an indicating voltmeter. Records of wind velocity, weather conditions and tonnage between stations were obtained and also a graphical record of the speed.

H. E. BRUNNER[4]:—One of the outstanding features of antifriction bearings is their dependability, and there is something to be gained in rolling resistance. According to our tests, the running resistance of a train varies between 4 and 10 lb. per ton, depending upon the speed. The starting resistance is much higher, about 35 lb. per ton. With antifriction bearings, properly applied, the starting resistance can be reduced to about 4 lb. per ton. That means a considerable saving in the power required for starting.

Proper mountings of bearings is worthy of careful consideration. Each bearing must be free to conform to any position that the wheels cause the truck to assume. Provision must be made for proper lubrication and for keeping dirt out of the bearings.

Antifriction bearings have been applied to railroad cars since 1910. We now know of about 700 cars so equipped operating on trunk lines, with weights as great as 95 tons per car. It is safe to apply antifriction bearings to railroad cars where the loads are supported substantially and the journals are in the American Electric Railway Association classification.

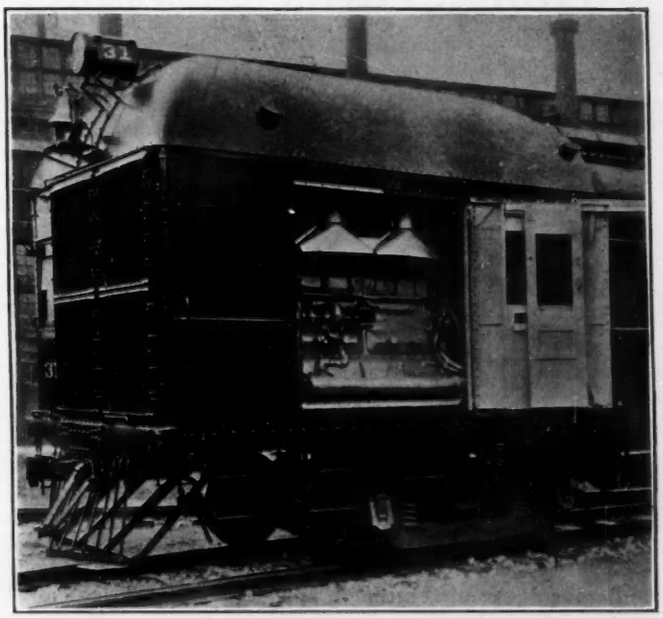


FIG. 6—ENGINE COMPARTMENT OF BRILL-WESTINGHOUSE RAIL-CAR
This Shows the Forward End of the Car in Fig. 5, with a Door to the Engine-Room Open for Access to the Powerplant

[3] General manager, railway division, Timken Roller Bearing Co., Canton, Ohio.
[4] M.S.A.E. — Chief engineer, S K F Industries, Inc., New York City.

Low-Cost Fleet-Operation Methods

VALUE attaches to the three papers and discussion that follow because of the practical information given on operating and maintenance methods practiced by companies operating fleets of vehicles of mixed character from points widely separated in a large territory. The symposium was presented at a meeting of the Southern California Section held in Los Angeles on Nov. 12, 1926.

Each paper deals with the subject of low-cost fleet-operation in general, the respective authors giving their views and practices with regard to methods of keeping operating and maintenance costs as low as possible. Mr. Bussey, in the first paper, describes a system whereby a mixed fleet of widely scattered vehicles is serviced through main stations and at locations as remote as 300 miles from a main station. Traveling mechanics make light repairs on equipment outside of the main-station territory, inspecting the vehicles every 30 to 60 days. The unit-repair system is employed for making major repairs when it is impracticable for a vehicle to be sent to a main station, where spare units are kept in stock. Some details are also given on general overhaul and painting methods and on means employed for avoiding engine trouble and reducing fuel and oil consumption.

In the second paper, by Mr. Rondot, three main problems of the transportation manager are listed, and a brief outline is given of the system used by the company with which he is connected in operating and maintaining a fleet composed of 31 different makes of vehicle serving 10 counties in California.

Shop organization, supervision, inspection, system and intelligent use of proper service-equipment are specified as factors in economical fleet-maintenance by Mr. Rutherford in the third paper. This deals with methods followed in maintaining a fleet of 29 makes of passenger-car and motor-truck. The "trouble-shooter" is said to be a valuable man in the organization. Equipment coming into the central garage is worked upon by a night crew, a group of vehicles being assigned to each man. Field drivers are responsible for cleaning, greasing, and oiling their vehicles and tightening bolts and nuts. Economical results are obtained by the unit-repair system. Painting in the field with quick-drying paint keeps up the appearance and protects the vehicles from the elements.

The discussion relates largely to the bases of operating and repair costs and the difficulty of making comparisons. Although the operating cost per ton-mile is shown by one speaker to be influenced by many factors and is thought by several not to mean much, it is said by another to be necessitated in his trucking business by competition and to give closely corresponding figures on similar roads regardless of distance. Reported repair costs for a given operation are declared by another speaker to vary 100 per cent.

A contractor finds it of great value to know just what each driver and truck is doing and where they are at all times. He says that slow speed of operation does more than anything else to keep trucks out of the repair-shop. His drivers have nothing to do with servicing and repairing the trucks; each mechanic is responsible for the entire maintenance.

Maintenance of Widely Distributed Oil-Trucks

BY C. G. BUSSEY[1]

EVERY purchaser of a motor-vehicle immediately faces the problem of operating cost. Equipment that is owned and operated individually receives a personal care which is not present when hired operators are employed. As the number of units increases, it is necessary to detail someone who will be directly responsible for their operation and maintenance. With many fleet owners, their motor-vehicle department has the capacity of a large business-organization, both clerically and mechanically. Motor-vehicles, in whatever number, must be cared for properly or the investment is a loss; and the greatest "returns" are obtained from the greatest number of days the vehicle is on the road.

Detailed methods of up-keep employed by fleet operators vary somewhat with each individual problem. The company I represent believes the low cost of fleet operation begins with the correct selection of a unit for each individual project, records and experience being the guides to these selections. We have classified our work and have designated either a special make or a vehicle of a certain grade for each classification. The truck or passenger-car of each classification receives a specified amount of accessories and special equipment.

Tank and truck bodies are designed according to needs, and their equipment is as nearly standard as possible. Our motor-vehicles are widely scattered, there being perhaps hundreds at, or adjacent to, a main station. The remainder are in smaller numbers at locations convenient for operation or service. Some of our vehicles are more than 300 miles from a main station. Consequently, service and instruction bulletins must be issued from time to time to the local representative, who is held responsible for the correct handling and lubrication of the equipment in his charge. Any local repairs or purchases are made only after approval by our automotive department. In each district we have a number of traveling mechanics whose schedule calls for an inspection of all outside equipment every 30 to 60 days. They make light repairs and adjustments or may change service-units. They make a complete report on each piece of equipment to the automotive department, describing the general conditions, and they may make recommendations for major repairs.

Repairs on motor-trucks at distant locations are usually made by an exchange of units; but, wherever practicable, major repairs are made at a main shop, where, for the accommodation of the shop, a regular schedule is maintained. A list of repairs is sent to the shop with the equipment to be repaired, and another inspection is made there to avoid mistakes. An estimate of repair

[1] Union Oil Co. of California, Los Angeles.

cost is made from the shop inspection and this, with recommendations, is submitted to the automotive department for its approval before the work is started. In the large shops we carry spare engines, radiators, transmissions, differentials, steering-gears and shock-absorbers for such trucks as we have standardized. These units are used for outside installation and also on overhaul jobs where time is a factor.

Methods of Repair

All repair work is thorough. Crankshafts of overhauled engines are trued-up if necessary. Main and connecting-rod bearings are lined-up and bored with special tools. We use alloy pistons, except in Ford cars and some heavy-duty-truck engines, as they cause the engines to run more smoothly and minimize all wristpin and connecting-rod-bearing trouble. Also, from the viewpoint of the shop, the use of alloy pistons reduces the number of come-backs due to scored cylinders caused by operators who will not give an overhauled engine the same chance that they will give a new one. All overhauled engines are run-in by belt power at least 24 hr. before being operated under their own power. The running-in of the engines has reduced greatly the amount of engine trouble.

Recently we installed a number of precision valve-reseating tools. This tool has an adjustable outboard bearing-guide for the pilot and holds the cutter so that the valve-seat is cut concentric with the valve-guide. Many valve-seats are out of line in both old and new engines. We installed a new four-cylinder-engine block on a passenger-car recently and used the precision tool to check the valve-seats. It was found necessary to cut the original valve-seat away entirely on one side of all eight seats to obtain the proper alignment. We find that proper seating of valves greatly reduces the burning and noise. With some used passenger-car engines we have found a decided piston "blow-by" after the valves were reseated in the foregoing manner, and it has been necessary to install special compression-rings. Valve-seats that are in bad condition are bored out and a cast-iron ring is pressed-in to form a new seat.

General Practice and Records

Regarding the consumption of oil and gasoline, our research department has made extensive tests in carburetion and the development of motive power. This department also has tested governors, air and oil-cleaners and the like, and special tests are continually being made on a large number of paint samples.

We avoid engine trouble by paying special attention to valves, ignition, carbureters and gasoline filters. While dirt may not find its way into the gasoline tank directly, the movement of the gasoline in the tank causes a breathing action, and the incoming air drops the dirt which it carries before being expelled. A gasoline filter will pick up this dirt and keep it out of the carbureter nozzle.

Vendors of all sorts of mechanical appliances besiege us. To be abreast of the times we must try out a certain amount of new merchandise; but, since we cannot try them all, our experience causes us to make the three following classifications: worthwhile, interesting and impossible. Among some of the articles which have proved their worth are air bottles, which we install as standard equipment on all 2-ton trucks. The effectiveness of air bottles at the front on all heavy pneumatic-tired trucks is very noticeable, making them much more steady and more easily controlled. Air-cleaners are being made standard equipment; the life of an engine in the Imperial Valley has been increased at least 80 per cent since adopting them. We have made extensive tests with different types of governor with very gratifying results. Some of our districts are asking that all their trucks be equipped with governors.

We keep a complete record of both solid and pneumatic tires. All discarded tires are either inspected by the traveling mechanic or are sent to some main station for inspection. Each tire that is sent in has its own story of use or misuse. A study of tire conditions often results in increased mileage. Several years ago some of our ¾-ton trucks were equipped with 34 x 5-in. tires, having a bar tread-design. The rear tires were delivering 7000 to 8000 miles and the front tires only 5000 to 6000 miles. After some study we decided that the trouble must be with the amount of camber given the front wheels. Therefore, the camber was reduced from ¾ to ¼ in. per wheel and the toe-in between the wheels was reduced to ⅛ in. After this treatment the front-tire mileage was almost doubled.

On practically all balloon-tire-equipped cars we have found that reduction of the camber to ⅛ in. per wheel greatly increases the mileage and, in many cases, improves the steering ability. In reducing the camber it is necessary also to reduce the caster effect of the front spindles, otherwise a bad shimmy-effect may develop. This reduction is accomplished by inserting taper shims between the spring and the axle. The proper setting of the spindle is approximately 2½ deg. forward at the bottom. This setting varies somewhat with the general design of the car. Axles must always be bent cold. Education of our operators and the making of minor repairs have proved to be large factors in our effort to attain low operating-cost.

Problems of the Transportation Manager

BY E. M. RONDOT[2]

THE automobile industry has developed a need for a new profession, that of transportation manager. Practically all the companies operating a fleet of 25 or more motor-vehicles now have such experts, and the ever-increasing realization that motor transportation is a science in itself indicates a growing field for the man who understands the problems of this comparatively new business and how to solve them.

The main problems confronting the transportation manager at this time are means to secure low-cost fleet-operation. To obtain the best results he must

(1) Choose the type and make of equipment that is best suited for his particular line of work
(2) Have an organization to give service and proper maintenance
(3) Have authority to select and control all drivers and operators

The selection of drivers and operators has more to do

[2]Assistant superintendent, transportation department, Southern California Edison Co., Los Angeles.

with the cost of operation than any of the other items. This has been demonstrated in many ways. It becomes more evident in large-fleet operations than it does in the smaller ones. In many cases when drivers take out new vehicles and use them in the same kind of service, 25 per cent will drive approximately 25,000 miles; 25 per cent, 20,000 miles; and 50 per cent, 10,000 to 15,000 miles, and all the vehicles will cost approximately the same amount for repairs. Drivers can increase gasoline, oil and tire mileage considerably by operating the vehicles carefully and properly, and this helps to lower the operating costs.

General Organization and Methods

All organizations operating transportation equipment have devised systems for operation and maintenance to meet their own requirements. The following is a brief outline of the system in use by the company with which I am connected. The company's property extends from Big Creek, about 70 miles north of Fresno, Cal., to Capistrano on the south, and from the Pacific Ocean inland to Banning. It serves the 10 counties of Los Angeles, Riverside, San Bernardino, Orange, Ventura, Kings, Kern, Fresno, Tulare and Santa Barbara. In this territory the company operates about 1000 vehicles of 31 different makes, of which 40 per cent are passenger-cars while 60 per cent are commercial vehicles. To maintain and service this equipment there are 34 district garages and one general garage. Each district garage houses and services from 10 to 40 vehicles. All major repairs and general overhauling are done at a general garage, located at Los Angeles.

Districts operating up to 12 vehicles have one mechanic; districts with more than 12 and up to 22 vehicles have one mechanic and one helper; districts with more than 22 and up to 30 vehicles have one mechanic, one helper and one car-cleaner. These men service and clean the vehicles and do all minor repairing. Traveling supervisors have charge of these men and supervise nine districts each. They cover the districts in their divisions, checking the equipment, assisting with repairs and analyzing the transportation conditions in the field.

District mechanics secure approval from their supervisors for all repairs costing from $10 to $50. When repairs cost more than $50, an estimate is made and sent to the general garage, where an analysis is made and approved by the superintendent of transportation before the work is started. When an overhaul is necessary or the repairs amount to more than $100, the vehicle is sent to the general garage and it is decided whether it is to be overhauled or retired. If the analysis shows that the vehicle has been abused, the operating conditions are investigated, the person responsible is reprimanded, and discipline is applied according to rank.

In cases where several persons are responsible for the abuse of a vehicle, such as in line gangs in which the crew makes no effort to keep its truck in good condition and damages it by taking it into locations where a truck is not built to go, the crew usually is given an old truck that has been used by a careful gang and the new equipment is assigned to the careful gang. This system is carried out to a great extent with all company vehicles.

Vehicles for the entire system are supplied through orders from the superintendent of transportation. When a district or department wants a vehicle replaced, a request is made to the transportation department, which analyzes the vehicle in question and either replaces it or has it overhauled. When additional vehicles are required, a department or district makes a request, and, when approved by an executive in charge of that department or district, it is sent with his approval to the superintendent of transportation, who selects and supplies the equipment.

When a new vehicle is purchased it is delivered to the general garage, where it is recorded, given a complete mechanical check, serviced, equipped with all necessary accessories, and run-in for 300 to 500 miles by careful drivers before it goes into regular service.

It should be noted that almost every angle of expense is covered by some one who is interested in the cost of operation of the vehicles and that, in this manner, we secure low-cost fleet-operation.

Mixed-Fleet Maintenance Methods

BY R. R. RUTHERFORD[3]

ECONOMICAL fleet-maintenance depends upon organization, supervision, inspection, system, and intelligent use of correctly designed service-equipment. It is much easier to maintain a fleet of vehicles of one make than a fleet made up of various makes. The operator whose fleet is standardized can utilize specialists, use the unit-repair system to advantage, and install the proper service-equipment to handle the particular make of vehicle he has adopted.

The fleet under my jurisdiction is composed of 29 different makes of passenger-car and motor-truck, and the methods I shall outline can be considered from the viewpoint of the operator of a mixed fleet. Although standardization has its advantages, when a large fleet is to be considered it may, on the contrary, be advantageous not to limit it to any particular make of vehicle because there is then no direct method of comparing one make with another.

The mechanical force must be selected according to its knowledge of the various vehicles and general repair-methods. In forming a shop organization, the fact must be considered that, in motor-vehicle work, practically all branches of the mechanical arts are included. It is well for the foreman to study the men as to their ability to perform certain operations. One man may show greater ability to recondition the transmission and rear-axle units than to recondition the powerplant, or a man may be more expert on brake, steering-mechanism or electrical-unit repair than the other men are. This close observation of the men and their adaptability to certain phases of motor-vehicle-equipment reconditioning will develop a smooth-running organization and will speed-up the work at the minimum cost for labor without reducing the quality of the work.

The so-called "trouble-shooter" is valuable in any general shop that demands quick service on the cars of executives and on motor-trucks that are in trouble on the road or are out of service on account of minor defects that can be remedied quickly after expert diagnosis.

[3] Standard Oil Co. of California.

Some mechanics have a natural ability for this class of work and can be relied upon to make an intelligent diagnosis of necessary repairs when the vehicle comes in for general overhauling, and also to make the final inspection and road test after the overhauling is completed.

Inspection and System

Frequent and thorough inspection and service work are essential to economical up-keep. Equipment coming into the central garage should be worked upon by a night crew, the number of men depending upon the size of the fleet. These vehicles can be grouped and a group assigned to each man. Periodically, he should check the ignition system, drop the crankcase for bearing inspection, grind valves, inspect wheel-bearings for looseness, and the like. He should check the ignition about once every 2 weeks, drop the crankcase about every 5000 or 6000 miles, and grind valves after each 4000 miles of operation or more often if the engine shows lack of power, poor compression or valve-stems that stick. This group method assures mechanical service on the vehicles. It places responsibility on the men, creates a certain pride in their own small fleet and eliminates partiality. By partiality, I mean selecting the vehicles for the men by the man in charge, or allowing the men to choose their own work. The foreman may not intend to show partiality, but the men believe he is favoring some certain one, which soon causes friction. The method causes the vehicles to be grouped so that the old ones are given as much attention as the new ones.

Regular and periodic inspection, and repair at the time of inspection, are accomplished in like manner by the field mechanics, except that the vehicles do not come into a central garage but are located at a number of stations. This system is to take care of a widely scattered fleet. The mechanic for the field work is selected in accordance with his ability to locate trouble in certain parts of the motor-vehicle quickly and to make repairs or adjustments needed to put the machine into proper working condition. He must possess a certain amount of executive ability and resourcefulness, as he is located away from the general shop and in many instances must rely on his own judgment in emergency cases. He is in direct contact with operating conditions and incidentally educates the drivers in the proper care and operation of their equipment.

The field drivers are responsible for cleaning the vehicle, greasing and oiling it and tightening bolts and nuts. Each driver is allowed enough time to take care of these items; he cleans his truck each day, washing it if necessary, greases all vital parts at least once a week, and spends an average of 2 hr. per week in tightening loose parts. He changes the oil in the crankcase after each 500 miles of operation. The work performed by the drivers allows the mechanic more time to maintain the vital parts of the vehicle.

This method of frequent inspection and close contact with the equipment assures us that the vehicles are mechanically fit to operate every day, and also brings out any predominant fault in design and construction. It means that there is no fixed rule on retirement. A truck or a car is kept in service as long as it functions with reasonable economy. General overhauling and painting are done when necessary, but as a broad general policy the equipment can stay away from the shop for long periods, often as long as 4 years, without a general overhauling. Painting in the field by the use of quick-drying paints keeps up the appearance and protects the vehicle from the elements. Although this method is looked upon with disfavor by the average painter, it keeps the vehicle in service and out of the paint shop until a general overhauling is necessary, at which time a first-class painting job can be done.

Economical results can be obtained by the unit-repair system. This provides for the carrying of a number of complete units that can be substituted readily for the worn unit, which can then be reconditioned after the vehicle is out on the road. It is not economy to keep a spare engine, for instance, unless there are at least 10 vehicles of the same make. Such items as springs, radiators and transmissions are kept in stock in proportion to the number of vehicles using them and to the rapidity of the turnover.

Service Equipment

Proper service-equipment is perhaps an expensive item for the operator of the mixed fleet. It is impossible to equip the shop with all the special tools for each vehicle, but with the speed wrenches and special tools for the servicing of the various makes of equipment, the most essential and most used tools should be available. Such tools as bearing-reamer sets, aligning jigs, valve-grinders, Ford overhauling-equipment, and many other tools of standard make, tend to speed-up the work and assure a much more accurate job than do the old tedious hand-work methods. Many useful service tips can be obtained from the different service-department agencies. I have found this service information of great value, and that it is always given courteously.

Many mechanics are prone to use their own judgment in the matter of clearances and adjustments, which causes loss of valuable time. The manufacturer's recommendations are easily obtainable and should be consulted frequently. This factor is well worth serious consideration, as it will tend to reduce labor costs in the shop very considerably.

Many improvements have yet to be made to further economy in fleet maintenance, as probably no other business exists in which there are more leaks that sap the profits; consequently, more opportunities of stopping such leaks are found in the field of motor-vehicle transportation than in any other business.

THE DISCUSSION

John E. Van Sant[4]:—After checking up with a number of fleet operators, I find a variation of as much as 100 per cent between their reported repair cost for a given operation. One great difficulty with which we must deal is in obtaining the actual cost of each individual repair operation that is performed on a motor-vehicle. We have made a study of this factor and find that the proper decision as to the correct operation needed to obtain the results desired is of primary importance. One great loss in connection with repair is due to the performing of incorrect operations. This may be due to poor diagnosis or to poor judgment. Better diagnosis will result in a material decrease in the total cost of any corrective repair operation.

Training the mechanics is an item upon which we have laid the greatest stress and from which the best results

[4] A.S.A.E.—General superintendent of service, Paul G. Hoffman Co., Inc., Los Angeles.

have been attained. In our shops, we first started with contract operations, and these were assigned certain letters or symbols. Each mechanic knew that we were keeping records of labor costs on these particular operations. We also sent through the shop similar operations which did not bear the symbol. As a result, we found a variation from 50 to 100 per cent in the cost of an operation, according to whether the mechanic knew or did not know that they were being checked on labor costs.

J. J. CANAVAN:—Is it not true that cost per mile does not mean much? Compare operating a motor-truck in the city 15 or 20 miles per day with operating a similar truck in the country 50 miles per day. In the operation in the city in congested traffic, the gasoline mileage is 50 per cent less.

ETHELBERT FAVARY[5]:—Many factors enter into the question but comparisons may be made as to cost per mile if running cost only is considered, for instance. Of course, the overhead and depreciation vary greatly.

MANY FACTORS AFFECT TON-MILE COST

CHAIRMAN EUGENE POWER[6]:—I also am of the opinion that cost per mile does not mean very much. Each operator has his own particular conditions to contend with, and it is very difficult to establish any uniform basis of comparison. For example, try to compare a fleet of trucks used in delivery service with one used in dump-truck service. I believe that these cannot be compared on the same basis because a dump truck carries its load from the point of inception to the point of delivery without stop, which is, in a way, the ideal condition. The shorter the mileage traveled is, the more effective is the work that can be done in one day, after deducting loading and unloading time. For example, if a haul of 5 miles is made at a speed of 10 m.p.h., the outgoing and return trips can be made in 1 hr. Allowing 15 min. for unloading and 15 min. for loading, the total time is 1 hr. 30 min. For double the distance the running time would be twice as long. The higher the mileage is, the greater is the tendency to secure a lesser cost per mile, due to the fact that certain fixed operating charges, such as gasoline and oil consumption, tires, drivers' wages, and depreciation, are apt to be reduced to a certain extent with an increase in mileage when they are computed on a mileage basis.

The reverse condition applies in city operation, where many stops must be made, due to traffic control; hence smaller mileage does not necessarily mean larger output. Consequently, it is very difficult to establish cost per mile as a basis for making delivery estimates. An individual owner can use cost per mile from a maintenance or from a mechanical standpoint to contrast operating expenses of units of the same size engaged in the same work. He has a basis there for comparing operating costs; but when other charges such as depreciation, taxes and the like are included, the estimates are thrown out of balance from a purely mileage standpoint. In our particular case, and I assume it is the same with most companies engaged in a so-called peddling or delivery business, the less mileage we get and the greater the output is, the less is our final cost per gallon of oil delivered, and that is what we want; but unless the operating conditions are known, it is sometimes highly misleading to judge a unit of an automotive fleet by its operating cost alone.

Recently, we analyzed the cost of a 5-ton unit, including driver's wages, depreciation, oiling, greasing, washing and all maintenance charges, and found that it was approximately 56 cents per mile. We had another unit working at about one-half of that cost, but having a higher average daily mileage. However, the truck costing 56 cents per mile was distributing approximately four times more gasoline than the other. Hence, our cost per gallon was less. That is why I think operating conditions must be considered when analyzing costs rather than relying purely on the cost per mile.

We use a mild form of unit-repair system; that is, a certain number of spare engines, depending on the number of fleet units reporting to a given shop. Some units are a long distance from the main shops where service is given. One station is 700 miles distant from the main shop. So we keep an engine ready to ship and, when the traveling mechanic reports that an engine will shortly need overhauling, the spare engine is sent out at about the correct time, is installed, and the old engine is sent in. The same practice is followed in connection with transmissions and differentials, but the necessity for changing them is not so great.

W. C. BROWN[7]:—We compile statistics on the cost per mile and on the cost per hour, because we have large trucks on short hauls that run only 7 or 8 miles in 8 hr. Our figures enable us to compare one truck with another truck of the same make and capacity.

VALUE OF KEEPING TRACK OF DRIVERS

MR. FAVARY:—What is considered the most effective factor in reducing cost of operation?

F. H. ASBURY[8]:—Speaking from the viewpoint of a contractor, the most important thing is to know what the fleet is doing. If a driver is sent 100 miles from home with $10,000 worth of equipment and is expected to bring that equipment back in as good condition as when it left, one must know what he was doing while he was away. He cannot be expected to depend upon his own ingenuity or intelligence to care for the vehicle, so the thing is to know what his operation is and where he is going. We have adopted the practice of having some one of three executives ride in the seat alongside the driver, going over the route with him. Regardless of how far from home he happens to be traveling, some executive makes that initial trip. As an illustration, some time ago we had three loads for the same place a long distance north of Sacramento. The drivers were gone 8 days, without any supervision, and brought their equipment back in good shape. When occasion arose later to send five pieces of equipment over the same route again, one of the executives rode over the route and logged the trip. The drivers were then told what they were to do. They were to refuel at a certain place, eat at that place, sleep at another place, and be back at a certain time. The result was that the total time consumed on that trip was reduced from 8 days to 5 days, and the drivers had plenty of time to rest en route.

Another practice is our use of a messenger for routing trucks. If a truck is en route to some particular destination and an occasion arises, such as I have already related, in which it is impossible to reach the driver by telephone or telegraph, a messenger is sent to head the driver off and start him in whatever direction we wish him to go. To obtain this routing, we use a recordograph on each truck. The tape from each of those recordo-

[5] M.S.A.E.—Consulting engineer and manager of sales promotion, Moreland Motor Truck Co., Los Angeles.

[6] M.S.A.E.—Manager of properties, facilities and sales department, Union Oil Co., Los Angeles.

[7] Superintendent of motor-vehicle service, United States Post Office, Los Angeles.

[8] Asbury Truck Co., Los Angeles.

graphs is read after each trip; or, if there are a number of small trips during the day, we read the tape at the end of the day. The recordograph tapes are changed every 24 or 48 hr., as the case may be. Drivers who are located at foreign points and do not come to the home office, turn in their tape each day. If a driver's tape does not come in, his time is held up until we receive it. By knowing the routes over which the drivers travel, we can almost tell when they are eating, when they shift gears, and what speed they are making.

Another advantage in knowing what the equipment is doing, where it is, and how long it takes to travel from a certain point to a certain point, is that if, after leaving the point of origin, some other job arises which can be handled by that piece of equipment after it is unloaded, it is always possible to get in touch with the drivers. As an illustration, we had a truck en route to Taft, Cal., and a customer telephoned for us to bring some material back from Taft. Without having heard from the driver, who had left Los Angeles at 4:00 p. m. the preceding day, we told the customer at 10:00 a. m. that our truck would be at his place of business to load at 2:30 p. m. The driver's schedule was to be at his unloading point at 1:00 p. m. We telegraphed to the driver of the truck at 12:30 p. m. and he pulled into Taft 10 min. after the telegram arrived. Thus we made a large saving in being able to get a pay-load for the truck's return trip.

Slow Speed Keeps Trucks Out of Shop

Contrary to the experience of most operators, we find, that slow speed does more to keep the equipment out of the repair shop and to create a favorable impression upon the public than anything else we can do on the road. Our trucks, taken as a whole, average only 8 m.p.h. Some trucks run up to 10 m.p.h., but that speed is the highest. From 10 m.p.h. they run down to around 6 m.p.h., for a month's operation.

Another very important item in holding down the cost of fleet operation is to know what the gasoline and the oil consumption are. There are numerous ways of obtaining that information. Bills for gasoline purchased on the road from gasoline pumps must check with the gasoline consumed in the vehicles. There is no excuse for their failure to check. We transport quantities of gasoline in tank trucks, and we know that the evaporation losses are practically nil; so no reason exists for there being any losses through the trucks. If the bills and the gasoline consumed do not check, someone in the organization must explain where that gasoline went.

Driver's and Mechanic's Work Wholly Separate

We consider that a driver is simply a driver. He does not grease, does not make minor repairs, and does nothing except drive and load or unload his equipment. Some of the equipment comes to the yard and some of it does not. We make periodical inspections of equipment that does not come to the yard, and an accurate cost-record is kept on a ton-mileage basis. The driver is paid for his rolling time only, and receives a slightly higher wage than the average driver gets. The driver's job is to drive the equipment in such a manner that it will stay on the road. If his equipment has to go into the shop, the driver is compelled to lose the time that it is in the shop. He can sit around and watch the mechanic if he wishes, and find out what was wrong with his equipment and what he should have done to prevent it from coming to the shop. I do not favor very strongly the unit system of repairs.

In my opinion a mechanic is a man who can start at the crank in the front end of the vehicle, go through to the tail light and fix anything that is on there to be fixed. In so doing, the responsibility for the entire job is placed on an individual. It might seem that a large amount of money would thus be tied up in equipment out of service while it is in the shop and that otherwise might be on the road, but we find that the amount of money tied up in idle equipment being repaired in the shop is not nearly so large as the amount needed to stock replacement parts.

Another method we use in reducing costs of operation is as follows: If a mechanic needs, or says he needs, a new bearing, the bearing is never purchased until some one of our three executives has looked over the old bearing and passed upon the need for a new one. To turn out what they call a first-class job, mechanics often will throw away material which would still render a great deal of service if reinstalled in the proper way.

Greasing is done by a man who does nothing else. On inspecting five pieces of equipment that were greased by a substitute greaser on one occasion, we found something like 30 grease-cups that had not been touched; but this substitute had no thought other than filling out the day, while the regular greaser who had been kept continuously on that job and knew that, if a bearing did not receive lubrication, it would be blamed on him, was very careful in greasing.

Ton-Mileage versus Hourly Basis

Ultimately, our costs are figured down to a ton-mileage basis. It is necessary for us to maintain our costs on that basis on account of competition with other methods of transportation which use a ton-mileage or a tonnage rate. A number of hauls for, say, a 5-ton truck and trailer can be handled for $2 per hr. for the time that the equipment is on the job. Other hauls cannot be handled for less than $5 per hr. on an hourly basis. But on a ton-mileage basis, hauls over similar roads, regardless of the distance, will figure out within a fraction of a cent of the same cost. The haul from Los Angeles to Taft, Cal., for instance, is a long hard grind. On an hourly basis, or on the basis of the time consumed, our practice is usually to charge $3.50 per hr. and upward for a 5-ton truck and trailer. No individual who is hauling over this route will average $3 per hr. for a 5-ton truck and trailer; however, if the cost is computed on a ton-mile basis, the majority of the haulers are receiving compensation that is in keeping with the cost of the haul.

Mr. Favary:—Concerning Mr. Asbury's reference to the fact that he does not consider the unit-repair system economical, he should bear in mind that his operating conditions are different from those of the oil companies, which have numbers of trucks of the same size. Their keeping extra engines may be a small item; but, with fewer vehicles, it may be a large item, and so both may be correct in their statements.

Again I ask, what items are most effective in reducing the cost of fleet operation?

R. A. Love:—Inspection and transportation details.

J. R. Levin:—Inspection and lubrication.

V. D. Generaux:—I agree with Mr. Van Sant that some of the excessive operating costs may occur in the shop. I believe that a practical diagnosis of the trouble and proper supervision are the most important factors.

Activities of the Sections

ARMY ORDNANCE DEVELOPMENTS

Society's Presidential Nominee Tells the Pennsylvania Section of Post-War Advance

A golf tournament; a dinner; an address by William Guy Wall, nominee for President of the Society; and professional entertainment comprised the program with which the new meeting season of the Pennsylvania Section was started off on Sept. 23. All parts of the affair were thoroughly enjoyable, more than usually fine weather favoring the golfers at the Philadelphia Country Club in the afternoon and those who attended the dinner session in the evening at the rooms of the Philadelphia Automobile Trade Association.

Norman G. Shidle, editor of *Automotive Industries* and Chairman of the Section, opened the evening session following the dinner and made a preliminary announcement of plans for subsequent meetings. In place of the regular Section meeting in October, members of the Pennsylvania Section will join with members from the Metropolitan and other Sections in a trip to the Aberdeen Proving Grounds of the Army on Oct. 6. Arrangements have been made for a paper on engine lubrication by R. E. Wilson of the Standard Oil Co. of Indiana, to be given at the November meeting. Subjects in prospect or contemplated for winter meetings are on developments in automotive fuels, steel processes, and maintenance and service. The subject of the April meeting will be city traffic, on which Miller McClintock, who has made traffic surveys in San Francisco, Los Angeles and a number of other cities of the Country, is to present a paper; and it is the hope of the Meetings Committee that the city officials of Philadelphia can be induced to attend and gather some ideas for the facilitation of traffic in the City of Brotherly Love. Toward the end of the Section's fiscal year, one meeting is to be devoted to the effect of commercial aviation on aeronautical design.

By vote of the members present, it was decided to hold the meetings of the Section at the headquarters of the Philadelphia Automobile Trade Association this season, as the reading-room affords opportunity for members to gather before the meeting and converse comfortably, and it is possible to find nearby parking space for cars.

Golf Prize Awards and Entertainment

After announcing that a load of responsibility had been removed from his shoulders by the consent of Dalton Risley, Jr., general manager and chief engineer of the Craveroiler Co. of America, to serve as chairman of the Membership Committee, Mr. Shidle requested Mr. Risley to preside over the rest of the meeting for the evening.

Following the delivery of his paper by Mr. Wall, the award of prizes in the golf tournament were announced as follows: Low gross score, 119, by Mr. Busby, prize, a set of silver-mounted sherbet glasses; "Kickers" handicap, 78, by William J. Mayer, prize, a leather belt and buckle; and high score for one hole, A. H. Packer, technical editor of *Motor Age*. Announcement was also made that the Service Association of Philadelphia had extended an invitation to the Pennsylvania Section members of the Society to attend its meeting on Sept. 29, to be held in the rooms of the Philadelphia Automobile Trade Association.

Interspersed with the announcements and before and after delivery of Mr. Wall's paper, the members were entertained with professional talent, including piano music, singing and dancing and a monologue of Jewish, Irish and Italian anecdotes.

The great advances made in Army automotive and rail ordnance and in anti-aircraft guns during the last 10 years were emphasized by Mr. Wall, who is Chairman of the Society's Army Ordnance Advisory Committee, by contrasting the equipment used during the World War with that with which the Army is now equipped and which will be seen in action at the Aberdeen Proving Grounds this month.

Before the war the Army had only one 16-in. coast artillery gun, he said, which had a maximum range of about 13 miles, whereas now it has a considerable number of 16-in. guns with an elevation of 65 deg. and a range of nearly 30 miles. These shoot projectiles weighing 2340 lb. and capable of penetrating 14 in. of armor at a distance of 48,000 yd. These were contrasted by the speaker with the German guns used in the war and which created so much excitement by dropping 8-in. projectiles in Paris from a distance of about 75 miles. As these shells weighed only about 56 lb., they did little damage, however. Since the war, the trend of coast-defense ordnance has been mainly toward railroad mounts. We now have about two dozen very effective 14-in. railroad-mounted guns that fire projectiles weighing 1500 lb. and have a range of nearly 26 miles.

Anti-Aircraft Guns Effective Now

Land guns for defense against airplane attacks have undergone great development, said Mr. Wall, and are no longer to be ridiculed, as will be seen in the demonstrations at the Aberdeen Proving Grounds. An especially good record has been made by the new 3-in. anti-aircraft gun which fires a 13-lb. high-explosive shrapnel shell having a velocity of 2800 ft.-sec. A newly developed fire-control apparatus for this is so made that, when the altitude of an airplane has been found by a stereoscopic height-finder, two manually operated telescopes control mechanism that transmits all data to the guns automatically, making all ballistic corrections and giving necessary information to the fuse setter. Each gun in the battery fires about 25 shots per minute. Sound-detecting horns detect the noise of an airplane at a distance of 10 miles at night, with an error of only ½ deg., so that searchlights can pick it out of the sky and the anti-aircraft guns can be trained upon it. Demolition bombs that can be dropped by a bomber airplane are now being made in sizes of 4000 lb. and larger and charged with high explosives.

One of the interesting developments has been that of the piezoelectric pressure-gage for measuring the pressure of explosion in guns. This is based on the theory that a quartz crystal will set up an electric current proportional to the compression pressure applied to it in an axis normal to its faces.

New Tanks and Crawler Tractors

In automotive equipment, tanks have undergone important development since the war. As the 40-ton tank was found to be too large and cumbersome and the 6-ton tank too small to carry proper gun-equipment, specifications were drawn for a 23-ton tank, and several of these have been built. The Packard Motor Car Co. was induced to build an eight-cylinder V-type engine for one of these that develops about 280 hp. at 1800 r.p.m. and has proved satisfactory. The tank has a maximum speed of about 10 m.p.h. and carries a 6-pounder gun in a lower turret that revolves through 360 deg., and also carries a machine gun in an upper turret.

The policy of the Ordnance Department for some time, said Mr. Wall, has been to test all commercial tractors that approach Army specifications to ascertain if they are suitable for military work, so that in event of war production in large numbers can be obtained on short notice. It has been found possible to adopt as standard the 2-ton Caterpillar tractor provided with rubber treads, the 30-ton Caterpillar, and the 60-ton Caterpillar, which is somewhat similar to the Ordnance Department's 10-ton tractor. One of the serious tractor and tank problems is to get a crawler

mechanism that will stand relatively high speed and will not be too readily broken by gravel.

Another great problem has been to find the best means of carrying cargo near the battle front, where the conventional truck is out of the question. The six-wheel truck with balloon tires is at a great disadvantage over badly cut terrain, and some form of crawler-track vehicle seems necessary or else trailers drawn by crawler-type tractors. After many experiments the latter system has been adopted except for the Tank Corps.

Three Types of Motor Gun-Mounts

Motor gun-carriages were one of the war developments, with the guns mounted on crawler tractors, but these have not met with much favor in the Army, although several are undergoing tests. Three types carry respectively 3-in., 4.7-in., and 155-mm. guns. The last has a range of 25,000 yd. and the carriage is driven by a six-cylinder Sterling engine with the cylinder-block inclined at an angle of 45 deg. to be out of the way of the barrel of the rifle. The mount has no frame; instead, a series of axles provide points of support for subframes that carry the various assemblies. The mounts weigh 45,000 lb. and have a speed of 12 m.p.h. Spur-gear selective transmissions are used but in one model two planetary transmissions are used for steering. Accurate tests of the spur-gear transmission used in the mount for the 4.7-in. gun were made at the Aberdeen laboratory and have led to the conclusions that the efficiency of a heavy transmission increases rapidly with load but varies little after the load for which it was designed has been reached; that the efficiency varies with the ratio, decreasing as the speed-ratio increases; and that the figure 0.97 may safely be used in design and estimates as the efficiency per contact at full bearing-load for heavy spur-gears of high-grade heat-treated steel, carefully machined and aligned and running on well-lubricated antifriction bearings.

MAINTENANCE INSPECTION MEETING

The date of the October meeting of the Southern California Section was advanced to Sept. 30 because of the expected presence in Los Angeles of Secretary Coker F. Clarkson on that date, following his attendance at the Aeronautic Meeting session in Spokane on Sept. 23.

The subject of the Section meeting was Inspection of Motor-Vehicles from the Standpoint of Maintenance and Repair. Speakers selected to talk on the symposium were P. H. Ducker, of the Southern California Edison Co.; R. H. Stalnaker, equipment engineer of the California Highway Commission; F. C. Patton, of the Los Angeles Bus Co.; and J. L. Ferguson, Los Angeles service manager for Pierce-Arrow cars. On the program also was a paper on Inspection and Maintenance of Axles, by P. W. Sloan, service manager for the Timken Axle Co., and C. H. Jacobsen, service manager for the Moreland Motor Truck Co.

"MET" SECTION STARTS THE SEASON

The "Met"-Section Frolic held last year at the Manhasset Bay Yacht Club was enjoyed by so many and created so much interest in the Society among a number of prospective members that it was decided to start the 1927 season with a similar "get-together." The members, with their wives, met at the S.A.E. Headquarters on Sept. 15 and drove out to the Club, which is located on Manhasset Bay, Long Island, the scene of last year's Gold Cup Motorboat Races, in de luxe motorcoaches of the latest types, which were furnished for the occasion by A. F. Masury, International Motor Co.; W. J. Sommers, White Motor Co.; L. E. Voght, American Car & Foundry Motors Co.; W. S. Peper, Yellow Truck & Coach Mfg. Co.; H. M. Williams, Pierce-Arrow Motor Car Co.; and H. H. Hamilton, Studebaker Corporation of America.

Nearly 200 members and their guests attended the dinner and dance. Many favors were distributed to those present. These were donated by the Stromberg Motor Devices Co., Hyatt Roller Bearing Co., SKF Industries, Inc., and Feroda & Asbestos, Inc. Music continued throughout the evening until the very respectable hour, for New York City, of 12 midnight, and a number of novelty dances were staged, prizes being awarded which had been presented by the Bakelite Corporation, North East Electric Co., Rajah Co., Chicago Electric Mfg. Co., Westinghouse Air Brake Co., Robert Bosch Magneto Co., Fenner-Grant Co., and Splitdorf Electrical Co.

The Committee and Board of Governors of the Metropolitan Section has requested that their appreciation be expressed, through The Journal, for the cooperation of the companies donating the use of the motorcoaches and the special prizes and favors.

It was felt by all that the Section got away to a good start for the season and every one agreed that the congenial spirit of the Frolic would do much to cement the Section into a successful body of friends working for the common good of the industry.

Future meetings scheduled for the year are all of the more serious nature, and a number of prominent speakers are expected to appear before the "Met" Section to present and discuss the various problems the automotive engineer is called upon to solve.

A cordial invitation is issued to all visiting out-of-town Society members to attend these meetings, which are always preceded by a dinner to allow the members time to enjoy a social hour before getting down to the topics of the evening.

OPENS SEASON WITH A FROLIC

More than 30 members of the Milwaukee Section and about a score of Chicago Section members enjoyed a completely successful get-together "summer frolic" meeting on Sept. 14, with which the Milwaukee Section opened its 1927-1928 season. The day was ideal for the golf tournament at the Westmoor Country Club, in which 45 participated. This was won by J. Stone, to whom was awarded the first prize of a set of golf clubs donated by the Nash Motors Co. Second and third prizes were won by Cyrus Cole, of Williams, Cole & Wolff, Milwaukee; and Roger Birdsell, of the Racine Radiator Co., Racine, respectively. The prize for horseshoe pitching was won by J. W. Tierney, of the Electric Storage Battery Co., Chicago.

Forty-five members of the two sections partook of the 6 o'clock banquet in the clubhouse, after which they were entertained by the reading of a paper satirizing The Automobile of 1948. The meeting adjourned at about 9 p. m., with all agreeing that the occasion had been most enjoyable.

CLEVELAND SECTION FROLICS

Nela Park Provides Worthwhile Instruction and Recreation at Opening Meeting

Lectures and demonstrations in the Nela School of Lighting that followed the delectable get-together luncheon served at Nela Park to the 111 members and guests of the Cleveland Section, who attended the meeting held Sept. 17, were introductory features to the frolicsome sports at Nela Park Camp which were participated in during the afternoon.

The park and the camp, located on a commanding hill in the outskirts of the city, house the National Lamp Works of the General Electric Co., but the terraced lawns, winding driveways and pathways, trees, shrubbery, and flowers, together with the setting and architectural style of the buildings, combine to produce the effect of a university campus, which is wholly in keeping with the fact that the plant is an institution of learning and provides courses of instruction in illumination.

The honors for the success of the enjoyable affair go to Section Chairman S. L. Bradley, Lester M. Sears, B. H.

Event	Winners		Prizes	
	First	Second	First	Second
Balloon Race	L. E. Noble	E. K. Carlson	Parker pen	Tool kit
Crab Race	E. J. Horrocks	R. M. Riblet	Military brushes	Handkerchiefs
Volstead Act	H. R. Slusser H. D. Robb	Mr. Wiegman Mr. Greulich	Thermos jug	Thermos jug
Centipede Race	(Winning Team)—Clyde Pratt, S. E. Donahue, L. E. Noble, V. J. Swanson, and Messrs. Greulich, Wiegman and Egger		Seven flashlights	
Egg Tossing	Clyde Pelton	E. L. Jones	Cigar lighter	Cigar lighter
Distance Swim	J. W. Saffold	Mr. Chievitz	Pocket pencil	Measuring tape
Diving for Tin Plates	Mr. Chievitz	H. D. Robb	Field glasses	Pocket knife
Golf Putting	Mr. Sawyer	J. V. Whitbeck	Golf balls	Golf balls

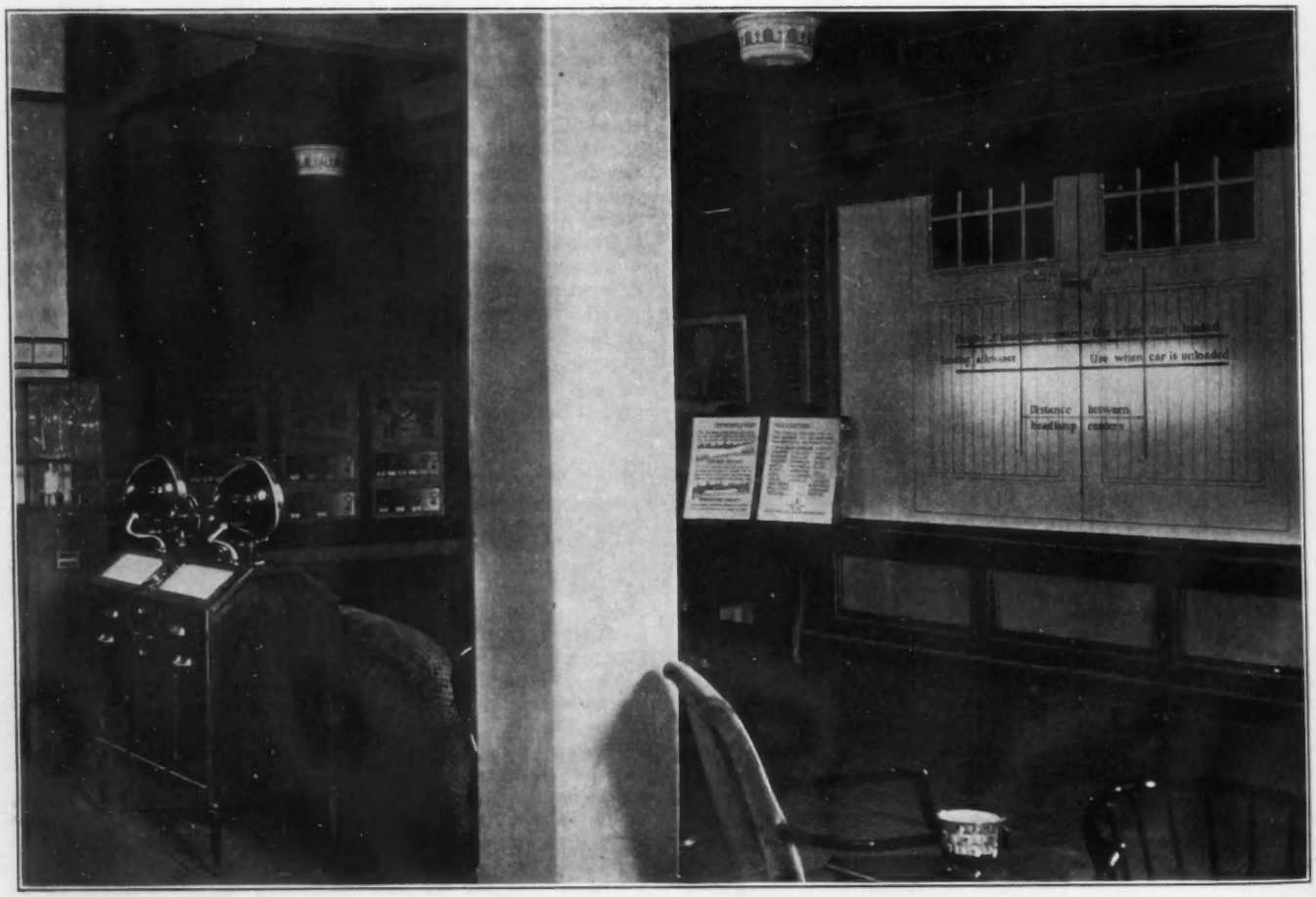
Blair, and W. E. England, for the painstaking thoroughness with which they handled the task of making the preliminary arrangements.

Expositions of Car and Building Lighting

Since artificial light is needed so that the daytime activities of mankind can be carried on after nightfall, and because this light must be efficient, comfortable and useful, researches and experiments in electric lamps and lighting are conducted continually by the engineering department of the company mentioned, to the end that the best light at the lowest cost can be furnished to the consumer. The school is therefore based upon the facts that light is necessary to vision and that the story of lighting progressiveness is best told visually. Elaborate demonstrating equipment is provided so that illuminating engineers and others actually can see what good lighting is and experience its advantages. Thus the school spans the gap between imagination and realization in that it forms a connecting link between the manufacturers who supply the lamps, reflectors and other equipment, and the consumers who utilize these products to obtain light. It is an educational activity where all who are interested in lighting are welcomed.

On this occasion interest centered especially on the lectures and demonstrations directly related to the automotive industry. Those on factory lighting, which has an influence on production; on street lighting, which affects motor-vehicle operation; and on office lighting, which bears on organization, were presented by L. C. Kent. An especially interesting feature was the model of a city street, one-sixteenth of full size, built to demonstrate a quarter century of progress in street lighting. Reverting to the days when street beacons blocks apart were used, it showed the street-lighting methods that one by one have given way to newer models demanded by modern requirements.

All the possibilities of lighting the motor-vehicle were explained and demonstrated by H. H. Magdsick. A model of a passenger-car, appropriately staged on a platform before the audience and equipped completely with lights, was used to illustrate the various points made by the lecturer,



Equipment Used at Nela Park Lighting School for Instruction as to Proper Method of Adjusting Head-Lamps

who turned the various lights on or off as he talked. A further and most interesting demonstration was made also with the head-lamps of the model and with various types of head-lamp now in commercial use. Beams from the commercial head-lamps opposed those from the head-lamps on the model, thus simulating the approach from opposite directions of two vehicles on the road. In this manner many of the defects of present-day headlighting, such as glare, faulty distribution, and insufficiency of light were shown and remedies were suggested. Deservedly, Messrs. Kent and Magdsick were warmly commended by many members of the Cleveland Section for their entertaining and instructive efforts.

Sports Events Afield

For comic relief from too serious an attitude toward the vicissitudes that attend life in this vale of tears, take, say, 100 overgrown boys, turn them loose on the greensward on a bright warm day in September and watch their antics. If anything can equal their ludicrous movements as about 50 men go slithering across a lawn toward a goal, their heads enveloped in thick brown paper bags so that they cannot see, and "walking" on hands and feet while bent over backward to imitate the crawling motion of a crab, we do not know what it is. Their varied abilities as to sense of direction, their changes of route and the locations at which they find themselves when the whistle is blown and the blinding bags are removed are hilariously funny.

But if they can be persuaded into performing the Volstead Act, the effect will be almost as side-splitting if there are numerous participants ranged opposite each other. Each is handed a stick about 3 ft. long, places one end on the ground, clasps both hands over the top, bends over and rests his forehead on his hands. He then revolves six times around the stick and runs immediately toward a designated goal. To overcome the dizziness thus generated, each individual needs to be equipped with a gyroscope or a dynamic balancing-machine or perhaps both. It he can run straight without such equipment, he is regarded as qualified to visit Windsor, Canada, ad libitum ad infinitum, whatever that means. Hence the Volstead Act.

S. L. Bradley
Chairman of the Cleveland Section

Raw-egg tossing between numerous pairs of participants is a gentle art, a fact not realized by some players. The equipment for the pick-up and get-away of a raw egg is as nothing compared with the sensitiveness of the braking system required to stop it safely and throw it into reverse. Engineers whose egg-braking systems are faulty either in design or application often find themselves "all wet." And it should be stated that the rumor hinting that real hard-boiled engineers use eggs that have been subjected to the heat-treatment process is untrue.

After uttering the further chirp that the distance racing of toy balloons of varied hue across green grass is a pretty sport involving many disappointments; noting that, on this eventful day, the gage pressure was 65 lb. per sq. in. as the winner of the balloon-blowing contest burst his balloon; and recording that he is said to have felt high-pressure tired after his effort, we shall desist. All the foregoing stunts were demonstrated during that happy afternoon at Nela Park, but as neither space nor words are adequate for all the details, the tabulation at the top of the opposite page must suffice.

Pleasant memories of the day's events certainly will linger in the minds of all those who attended the meeting.

FUSION-WELDING DEVELOPMENTS

Northern California Section Told How Improved Processes Can Be Utilized

Recent developments in arc welding have so improved the results produced that the process is likely to come into extensive use as a method of production in the automotive industry, and many of our ideas of design may be revised as a result, according to statements made at the first regular monthly meeting of the Northern California Section for the season of 1927-1928. The meeting was held at the Hotel Whitcomb, San Francisco, the evening of Sept. 8, Chairman W. S. Penfield presiding, and the speaker of the evening was James C. Bennett, manager of the automotive department of the Associated Oil Co., past-chairman of the American Welding Society, and member of the California State Advisory Committee on Welded Pressure-Vessels.

Reports of several Section committee chairmen were heard before Mr. Bennett was called upon to talk. Announced plans for the new season are of most interest. Chairman Fred L. Sargent, of the Program Committee; H. L. Hirschler, of the Papers Committee; M. J. Lephos, of the Entertainment Committee; and Secretary W. S. Crowell reported that meetings are to be held the second Thursday of every month in the new quarters of the Engineers Club, that programs are to be made up for 4 months in advance, that they are to be made so interesting and instructive that no member can afford to stay away, and that real entertainment is to be provided at the meetings. The next meeting, which will be held on Oct. 9, will be devoted to operation and maintenance. Harold Jarvis, manager of the Transportation Guarantee Co., will present a paper on Depreciation of Equipment on the Mileage Basis.

Fusion welding, which he divided into the three general branches of thermic, gas, and electric welding, has had its greatest development in the last 10 years, and in the last 3 or 4 years electric welding has rapidly overtaken the application of acetylene gas in the process, said Mr. Bennett. After describing briefly the several processes, he asserted that in gas welding there is a reduction in tensile-strength of the welded metal, and that electric-arc welding with the carbon electrode has a much more limited application than arc welding with the metallic electrode, which has many possible applications in factory production-work but is rather limited for field maintenance-work.

Resistance welding with the electric arc is used largely for body work and other light-metal jobs. In this process no additional metal is used, fusion being accomplished simply by raising the temperature of the metal at the joint due to the resistance of the passage of the electric current. The two parts to be joined are brought into intimate contact by pressure while the metal is hot enough to fuse. This is essentially a factory process and is limited chiefly to production methods.

Two recent concurrent developments in fusion welding, both made by the General Electric Co., are arc welding in a hydrogen atmosphere and atomic-hydrogen welding. The former is of exceptional value, said Mr. Bennett, because it is pointing the way to more reliable results from arc welding and is indicating how one of the serious problems in the development of this process will be solved. Atomic-hydrogen welding is likely to remain wholly a factory process. In this method heat is first developed by the electric

arc, which breaks down the structure of the hydrogen atoms. The dissociation of the atoms then produces a sufficiently high temperature to effect the welding.

Welds Stronger than Adjacent Metal

The superiority of arc welding in a hydrogen atmosphere instead of in oxygen, according to the speaker, is that brittleness of the metal at the weld is avoided and that welds can be obtained that have greater ductility and tensile-strength than the rest of the metal. A weld made in oxygen is very porous, whereas one made in hydrogen, a mixture of hydrogen and carbon dioxide, or with a special composition coating on the metal, results in extremely dense metal at the weld. This refers to steel in particular.

In a plant in Wisconsin visited by the speaker, where heavy welding is done and highly ductile metal at the weld is realized, an electrode is used that is coated heavily with a secret composition having the appearance of old-fashioned butcher's paper mixed with shredded asbestos. This composition seems to produce a slag on the surface of the metal that acts as an insulator to retain the heat within the molten metal so that as it cools slowly an opportunity is afforded for it to release more of the absorbed gas before it solidifies. By means of the electric arc, plates 2 in. thick were being welded to vessels about 6 ft. in diameter and 30 to 40 ft. long, and tests showed, asserted Mr. Bennett, that the welded metal had greater ductility and strength than the parent metal. This type of welded construction is being used on vessels to be operated at temperatures of 800 to 1000 deg. fahr. and with pressures of 200 to 250 lb. per sq. in.

Mr. Bennett described tests made within the last year by the Westinghouse Electric & Mfg. Co. to determine the relative strength of electric-welded and riveted structures. Prior to erecting a five-story structural-steel building, entirely welded, some columns of 10-in. I-beams, to some of which 6-in. beams were riveted at right angles and to others of which similar beams were welded, were set up vertically on the platform of a vibrating machine, secured by heavy foot-angles and holding-down bolts. The two test-specimens were vibrated 1700 times per minute by an eccentric having a 1-16-in. stroke. Four of the riveted members failed within 2 hr. 4 min., and within 4 hr. 15 min. two other members had developed a movement of ½ in. at their free ends. At the end of 18 hr. 20 min. no failure had started in or about the welds of the welded members; therefore, 25-lb. sections of 6-in. shafting were welded to the horizontal members and the vibrating was continued until 22 hr. 10 min. had elapsed, when the tests were stopped because the hold-down bolts failed from fatigue.

Must Revise Conceptions of Design

When we reach the point of thorough dependence upon welding, Mr. Bennett sees no reason for not welding motor-vehicle frames and other chassis parts, building framework and practically all structures in which rivets are used now. In doing this we must abandon old conceptions of design. We may find that we shall get away from structural shapes which are accepted as a matter of course today. For example, it is conceivable that sharp angles, which are weak points in the chassis frame, may be eliminated. Demonstrations made in almost every-day applications of welding lead him to believe, asserted Mr. Bennett, that all of the chassis problems with which we now contend have been met at least partially in some field in which fusion welding has been applied. A weld kept in straight tension is highly dependable, and in designing welded pressure-vessels it has been found that, whereas overlapping plates are necessary for riveting, with welding it is better to butt the plates end to end. One highly enthusiastic manufacturer of arc-welding apparatus goes so far as to intimate, said Mr. Bennett, that the day is not far distant when cast iron and other cast metals will be largely replaced by wrought metal, because fusion welding will eliminate the need for a metal that can be poured to produce difficult shapes. He thinks that with fusion welding it will be possible to produce any desired shape, and that it will be stronger and cheaper that a casting. Mr. Bennett, however, declared that he was not able to stretch his own imagination to this extent.

Truck Frames Welded Successfully

Much interested discussion followed presentation of the address. W. W. MacDonald told of building four trailers for steam shovels, of which two had riveted and two had welded frames. Both of the riveted frames have since had to be reriveted several times in many places and one became so bad that finally it was welded. He has since built seven welded motor-truck frames, using no riveting except where there is sheer stress. The welded frames, it has been found, will deflect uniformly over their full length, whereas riveted frames deflect unevenly. The riveted trailer structure was very heavy and inflexible. The welded structure was very strong. One of the trailers, he said, has been carrying a 29-ton shovel an average of about 400 miles per month and no failure of the welded frame has occurred.

R. J. Strecker, of the Peerless Welding Co., recounted some of his experience with acetylene and electric welding since 1913 and stated that whereas, 5 years ago, 80 per cent of the work of his company was gas welding, today the ratio of welding by the two processes is exactly reversed. Acetylene is used, however, on cast iron if it is desired to make sure of a good job. On the steel frames of trucks almost all the welding is electric, but in every case of a broken frame a butt weld with gas is made and a reinforcing patch is electrically welded under the break.

Riveting of automobile frames could be done away with entirely, in the belief of Mr. Strecker, as his organization has welded a great many truck frames, lengthening some as much as 11 ft. without putting a bolt or rivet in the whole job, but reinforcing plates must be put at the proper locations to avoid making a stiff section close to a rivet.

H. L. Hirschler, of the Horace Remote Control, raised the question of welding heat-treated alloy-steel, and asked if any possible method is known of protecting or treating a welded joint in this type of metal so that the strength imparted to the metal will not be impaired by welding. Mr. Bennett replied that a great deal has been done in welding alloy metals but that, in welding, the metal is remelted, and this tends to separation of the ingredients of the alloy, so that the weld may not stand as much stress as the rest of the metal. To some extent this objection is being met in gas welding by the use of alloy rods. Considerable hope exists that advancement will be made in this direction through atomic-hydrogen welding.

On this subject Mr. MacDonald told of making some nickel ring-gears by bending them out of a continuous piece and welding the joint with English coated rod, which he always assumed was a composition of metal and slack lime that would throw off hydrogen gas and lime for the annealing process. Rings made in this way, with the electric arc, can be machined and handled as if they were solid forgings, he said, and no splitting occurs at the weld. When the ring is clenched and heat-treated, the gear comes out perfect and the weld cannot be detected.

Mr. Strecker stated that his company is using a great quantity of steady rod, which is thought to be the hardest piece of metal to be had, for coating shovel teeth or other parts that are subjected to abrasion, as the runners on road scrapers. When the surface wears down, it is coated with this hard rod. To avoid drawing the temper of the metal by applying excessive heat and getting too much heat penetration, a current of very low voltage and high amperage is used. This melts the surface to a depth of not more than 1-64 in., and ¼ in. of hard metal is added. Analysis of the weld shows that virtually no hardness at the surface, as compared with the original hardness of the rod is lost by this method.

Standardization Activities

STANDARD MOTOR BEARINGS PROPOSED

Ball and Roller Bearings Division To Formulate Specification for Motor Industry

One of the troublesome factors that have developed in the design of electric motors used in industrial machinery is the lack of standardization of the roller bearings used. This situation was discussed recently at a joint meeting of representatives of the manufacturers of industrial electric motors and of ball and roller bearings, the increased interest in standardization throughout the Country having been responsible for the consideration of this problem.

The result of the joint meeting was a decision on the part of the National Electrical Manufacturers Association to request the Ball and Roller Bearings Division of the S.A.E. Standards Committee to draw up a specification for electric-motor bearings, the Division being the only standardizing committee in existence in a position to consider the problem intelligently from an unbiased standpoint.

The Ball and Roller Bearings Division has sent out a questionnaire to the bearing manufacturers regarding the width of bearings they believe desirable for the inside and outside diameters of electric-motor bearing commonly used. It is believed that the widths decided upon can be selected to conform to the widths of double-row ball bearings at present specified in the S.A.E. Standard for this type of bearing, especially in the medium series.

The bore and outside diameters of the bearing will, it is assumed, be made to conform to the diameters specified in the International Standard for single-row ball bearings that is now being considered by the American Sectional Committee on Ball Bearings.

As soon as the Ball and Roller Bearings Division has formulated a tentative recommendation based on the information received in answer to the questionnaire, it will be submitted to the industrial-motor manufacturers and the ball and roller bearing manufacturers for comment.

When the Division is sure of the acceptability of the recommendation, it will be referred to the National Electrical Manufacturers Association. Further progress on this project will be reviewed in subsequent issues of THE JOURNAL.

LUBRICATING-OIL VISCOSITY NUMBERS

Car Manufacturers To Cooperate To Increase Use of S.A.E. Specifications

The existing viscosity numbering system embodied in the S.A.E. Recommended Practice on p. 390 of the September, 1927, issue of the S.A.E. HANDBOOK, was discussed at a meeting of the Lubricants Division held on Sept. 9 in the General Motors Building, Detroit.

Considerable confusion has existed in the minds of car owners as to the correct grade of oil to be used in the crankcase for lubrication of a specific engine, and for some time suitable means have been sought for recommending the proper grade of oil. The value of the present viscosity numbering system as compared with the use of such terms as "light," "medium" and "heavy" was discussed by representatives from leading car manufacturers and oil companies and it was decided that, because of the commercial situation brought about by the use of brand and trade names, it would be virtually impossible to obtain any agreement among the oil companies on the use of these terms. Much favorable sentiment was expressed regarding the S.A.E. system of viscosity numbers and it was voted to retain this system as it stands and to determine a suitable means for putting it into wider use.

Representatives of the oil companies were requested to state their attitude toward printing the S.A.E. viscosity numbers on their can labels, as is the practice of one of the large refineries at present. Previous failure to do this has resulted from an apparent lack of demand, but in view of the expressed intention of motor-car engineers to recommend oils by the S.A.E. viscosity numbers, it is felt that all the oil companies will willingly cooperate by indicating these numbers on their labels.

Most of the motor-car engineers present expressed themselves in favor of recommending oils by the S.A.E. viscosity numbers in their instruction books, and it seems likely that one or two companies will have similar information stamped in the filler-tube caps.

The Standards Department will conduct a survey among car manufacturers and oil companies in which it will set forth those companies that have signified their intention to use this numbering system in this manner and request information as to what extent the cooperation of the others can be counted upon.

Prediluted oils do not at present fall definitely within any of the viscosity numbers and therefore a Subdivision was appointed, under the chairmanship of H. C. Mougey, of the General Motors Corporation Research Laboratories, to work in conjunction with a subcommittee of the American Society for Testing Materials in an endeavor to classify prediluted oils under their proper viscosity numbers.

ACTION ON ENGINE DISTILLATE

No Standard Specification To Be Recommended Owing to Limited Use

Acting upon a request from one of the tractor manufacturers that consideration be given to the formulation of a standard specification for engine distillate, the Standards Department conducted a survey of tractor manufacturers and oil companies to determine the feasibliity of such specifications. The many varieties of this fuel have caused considerable trouble to engine manufacturers, and it was felt that such standardization might overcome the difficulties experienced.

The subject was given due consideration at the Lubricants Division meeting on Sept. 9, but, inasmuch as the use of this fuel is confined to a few specific localities and because of the fact that it is virtually a by-product of refining, the Division decided that, even should the Society succeed in formulating a standard specification, the standard would receive virtually no recognition. It was voted, therefore, to table the subject until such time as engine distillate comes into greater and more universal use.

FAN-BELT AND PULLEY REVISION

Changes in Recommended Practice To Be Submitted to the Engine Division

A suggested revision of the present S.A.E. Recommended Practice for Fan Belts and Pulleys, appearing on pp. 13 to 16, of the September, 1927, issue of the S.A.E. HANDBOOK, has been prepared by J. B. Fisher, acting as a Subdivision of the Engine Division, for presentation at the next Division meeting.

Attention is called to the following items which constitute the major changes in the revised specification:

Table 1 has been omitted and a note on pulley diameters has been inserted

The illustration of the V-belt pulley has been changed to show the top of the belt extending above the pulley and a note has been added to the effect that the top of the belt should be not less than 1/16 in. above the edge of the pulley.

A note has also been added under the illustration of the flat-belt pulley indicating that the driving pulley only should have a crown face. A change will be noted in the paragraphs on angle of the groove, width of the groove, and angle of the belts, and a new paragraph has been added on the finish of pulleys.

In Table 2 the minimum depth of groove below the bottom of a 5/8-in. belt has been changed from 1/8 in. to 3/16 in. and a note on twin belts has been added to the table.

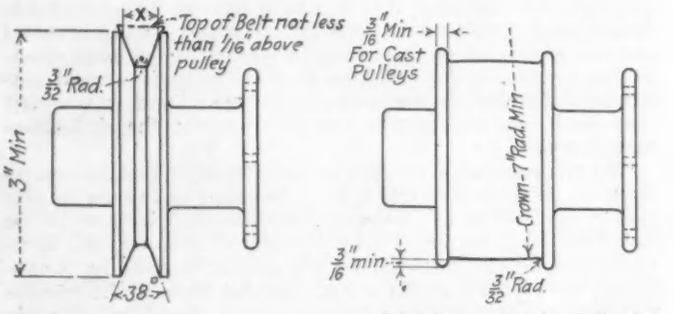
In Table 4 the maximum fan diameters for a 3-in. belt have been changed from 25 to 26 to read 25 to 28, and another set of dimensions has been added for a 3½-in. belt.

In Table 5, dimension *D* (diameter of spindle) for 1–1¼-in. belts has been changed from 0.748–0.746 to 0.873–0.871 in. as it was felt that this provides greater strength. In the same table the threaded hole, indicated as *N* in the accompanying cut, has been changed from 1/2–13 thread to a 1/2–20 thread for 1½–2 and 2½–3-in. belts, to prevent the adjusting screw from shaking out and to provide easier adjustment by virtue of the finer threads. A note on the length of the adjusting slot has also been added to this table. The thickness of the washer, indicated by *P*, has been changed for 1–1¼-in. belts from 1/8 in. thick to 3/16 in. thick, it being felt that a 1/8-in. washer will dish when the fan-spindle nut is tightened.

A note on the use of shrouds has been added to Table 6.

The standard 28-deg. belt is suggested for elimination, as the survey recently conducted showed that but two companies use belts with this angle. Inasmuch as the 38-deg. belt can be used for fans alone or for fans and accessories, it is believed that there is no need for two standards.

Complete specifications embodying the suggested revisions are printed herewith and comments and criticisms are invited.



Crown Face On Driving Pulley Only

TABLE 2—V-FAN-BELT AND PULLEY DIMENSIONS

Width of V-Belt at Top, In. *X*	Minimum Depth of Groove Below Bottom of Belt, In.	Maximum Fan Diameters, Inclusive, In.	Maximum Projected Blade Width, In.
5/8	3/16	Up to 14	1 5/8
5/8	3/16	15 to 18	1 7/8
3/4	3/16	19 to 20	2 1/4
1	3/16	21 to 22	2 1/2
1 1/4	5/16	23 to 26	2 1/2

Note:—For heavy industrial service, twin belts are recommended on fans 26 in. in diameter or larger instead of one wide belt.

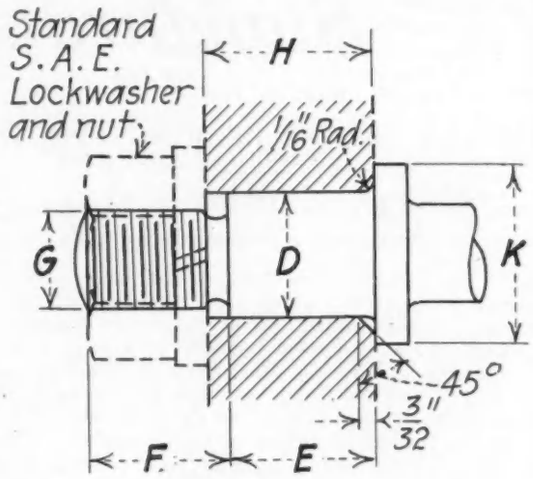


TABLE 3—FAN-PULLEY SPINDLES FOR SOLID FAN-BRACKETS

Width of Belt, In.	*D*	*E*	*F*	*G*	*H*	*K*
1–1¼	0.748 0.746	7/8	7/8	5/8–18	1	1
1½	0.873 0.871	1	7/8	5/8–18	1 1/8	1 1/8
2	0.998 0.996	1 3/8	15/16	3/4–16	1 5/8	1 1/4
2½–3	1.248 1.246	1 9/16	1 5/16	1–14	2	1 1/2

Fan Belts and Pulleys

(*S.A.E. Recommended Practice*)

Pulley Diameters.—To insure long belt life, diameter of fan-driven pulley should be made as large as possible consistent with size of fan. Recommended diameter of fan-driven pulleys not less than one-fifth diameter of fan and not less than 3¼ in. in any case. Diameters of fan pulleys to be given in increments of not less than ¼ in.

Angle of Groove.—An angle of 38 deg. shall be used for driving fans only or fans and accessories.

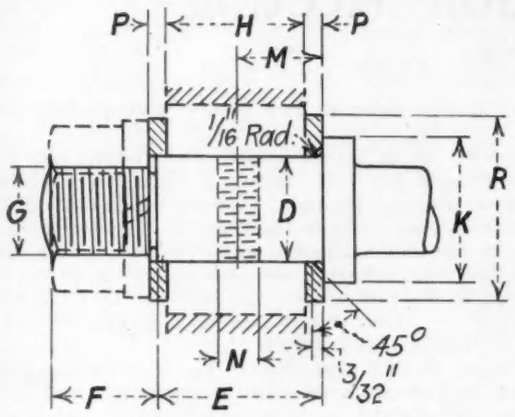
Width of Groove.—The width of the pulley groove measured at the outside diameters of the pulley shall be equal to the width of the belt. For link-belts the next larger size pulley should be used.

Angle of Belts.—The included angle of the sizes of rubber belts shall be 42 deg. to allow for the bulging

TABLE 4—FLAT FAN-BELT AND PULLEY DIMENSIONS

Belt Width, In. ±1/32	Pulley Width, In. ±0.01	Maximum Fan Diameters, Inclusive, In.	Maximum Projected Blade Width, In.
1	1 1/8	Up to 14	1 5/8
1 1/4	1 3/8	15 to 18	1 7/8
1 1/2	1 3/4	19 to 20	2
2	2 1/4	20 to 22	2 1/4
2 1/2	2 3/4	21 to 24	2 1/2
3	3 1/4	25 to 28	2 1/2
3 1/2	3 3/4	29 to 32	2 3/4

Length of slot to allow for ½ in. take up per foot of belt length.



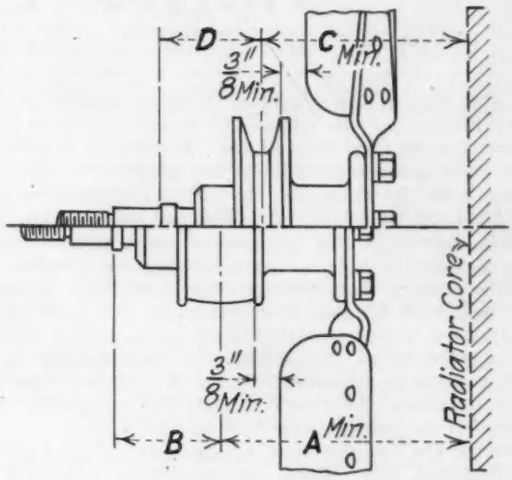


TABLE 5—FAN-PULLEY SPINDLES FOR SLOTTED FAN-BRACKETS

Width of Belt, In.	1–1¼	1½–2	2½–3
D	0.873 0.871	0.998 0.996	1.248 1.246
E	1 3/16	1 9/16	1 7/8
F	13/16	15/16	1¼
G	5/8–18	¾–16	1–14
H	1	1⅛	1½
K	1	1¼	1½
M	5/8	13/16	1
N	5/16–18	½–20	½–20
P	3/16	¼	¼
R	1⅜	1¾	2

of the inside of the belt when laid around the pulley. The included angle of leather belts shall be 38 deg.

Finish of Pulleys.—Driving surfaces of pulleys shall be smooth and free from tool or chatter marks.

TABLE 6—FLAT AND V-BELT FAN-ASSEMBLY DIMENSIONS

Belt Widths, In.		*A*	*B*	*C*	*D*
Flat	*V*				
....	5/8	...	...	3⅛	1½
...	¾	...	...	3½	1¾
1	1	3¾	1¾	4	2⅛
1¼	1¼	3¾	1¾	4	2⅛
1½	...	3¾	1¾	...	...
2	...	4¼	2	...	...
2½	...	4¾	2½	...	...
3	...	4¾	2½	...	...

When no shroud is used, front edge of fan blade shall be not more than ¾ in. from core. When shroud is used, front edge of fan blade shall be located from 2½ to 3½ in. from core.

Rear edge of shroud shall be flush with rear edge of fan blade.

J. SHEPPARD SMALLEY

IN a trial trip of a motor rail-car of his own design, J. Sheppard Smalley fell from the door of the car as it was crossing a 40-ft. trestle on the railroad between Tawanda, Pa., and Buffalo, on Aug. 11 and was killed instantly. The car was built at the Davenport Locomotive Works, in Davenport, Iowa, and last June Mr. Smalley, accompanied by C. H. Vandervoort of Moline, Ill., and an operating crew, started East to demonstrate it for the Susquehanna & New York Railroad.

Mr. Smalley, who joined the Society in June, 1923, with the grade of Member, was born at Muscatine, Iowa, in 1885 and was graduated from the Armour Institute of Technology in Chicago in 1907, with the degree of bachelor of science in electrical and mechanical engineering. From 1909 to 1915 he conducted the Smalley Auto Co. and the firm of Smalley & Halling, at Muscatine, as owner of the former and a partner in the latter. From 1915 to the time of his death he specialized in gasoline rail-car designing and building, successively with the Chicago, Milwaukee & St. Paul, the M., B. & S., and the Arizona & New Mexico Railroads; the A. Meister Sons Co., of Sacramento, Cal.; and the Smalley Rail-Car Co., of Davenport, Iowa.

Correction for Operation and Maintenance

THE footnote to the article on Cost Problems of Motor Carriers, by Franklin D. Howell, printed on p. 228 of the September, 1927, issue of THE JOURNAL, refers to Mr. Howell as Vice-Chairman of the Operation and Maintenance Committee of the Society, whereas he is a member of the Committee. E. C. Wood, superintendent of transportation and general shops with the Pacific Gas & Electric Co., San Francisco, is Vice-Chairman of this Committee.

The 1927 Production Meeting

(*Continued from p. 347*)

Motor Car Co., at the Thursday evening session in Detroit. Eugene Bouton, of the Chandler-Cleveland Motors Corporation, presided as Chairman of the Time-Study Session.

Most time and motion studies are made with the object of reducing both the time and the effort expended on a given task. Different systems of wage payment, even straight day-work, have felt the influence of such studies, but their value goes beyond their influence on wages and rates, according to the author. Rate-setting often ends when it has determined that, with the necessary allowances, a given operation will require a certain number of minutes, and a piece price has been determined from this. An improvement is to add another column so that the capacity of both the man and the machine is shown. This may indicate the possibility of using time wasted on another machine or operation.

A second use for the time study is found in maintaining a machine-load file. When the production schedule is increased, such a file will indicate quickly which machines are capable of producing the added amount. This information can be used for conveyor equipment and other forms of industrial equipment, and it may save the provision of additional factory space, as well as the purchase of unneeded equipment. Information of this sort is of use also in the stores department, in the employment department and in planning inter-plant transportation.

In the discussion, Chairman Bouton said that in the Chandler plant graphic paper is used for compiling machine-load charts. This makes the information available at a glance.

Elias N. Sawyer, of the Cleveland Tractor Co., reported using a machine-load record which works the same with the group system as with an individual machine. In one case this record made possible a certain rearrangement of machines which saved the purchase of a $12,000 machine for a certain job. This record has been found essential for the proper management of the factory. Its installation was a large task, but it requires very little effort to keep it uptodate.

The automobile industry was credited by Erik Oberg, editor of *Machinery*, with being one of the few industries that keeps adequate records of this sort.

Time Study and Labor Budgets

A paper on The Relation of Time Study to Labor Budgets, by E. J. Frounfelker, of the Continental Motors Corporation, printed in this issue of THE JOURNAL on p. 386, was then read.

In answer to a question, Mr. Frounfelker said that he seldom reduces the rate on a job when the operators are earning an unusual amount. Under a bonus system in effect the extra income is divided among the members of a group, and since the cost estimated in the budget is not being exceeded, the rate, although not guaranteed, is rarely changed unless an increase in production, or some other changed condition, enters. When this is necessary, an agreement is readily reached after consultation.

Chairman Bouton said that in his organization the rates originally set are understood to be temporary and subject to modification, upward or downward, after a period of trial. Mr. Sawyer asked if the time-study man could predict the work of a tool designer, and Mr. Frounfelker explained that the time studies are submitted to the tool division before tools are made, and if it is impossible to design a fixture such as had been anticipated, it is possible to change the budgeted figure before the figure has been announced.

The paper was commented upon by Edward W. Bernhard, of the L. H. Gilmer Co., as explaining a very useful short-cut in time budgeting. Making time studies for only the exceptional cases effects a real saving, he said.

Attention was called by Chairman Bouton to surprising economies that have been effected by budgeting shop supplies. At the same time, when no tool breakages are being reported on a job, that sometimes serves to show that the speeds and feeds on the job are too slow.

In the manufacture of bodies, said Paul Pleiss, of the Edward G. Budd Mfg. Co., many operations are performed by workmen who have not acquired skill, at least in the particular operation assigned them. The result is that the speed is constantly increasing for some time. It is not uncommon for a man to increase his production in the ratio of 10 to 1 in the course of a few months. This brought out the information that in several plants the rate of a new workman is made low until he has attained a normal production. In some cases a man is paid for several days at the charge of labor turnover without charge to the group with which he is working.

Mention was made of the fact that some companies have effected considerable economies by the introduction of women in various classes of machine and assembly work.

1927 Production Meeting Registration

ABELL, HARRY C., engineer, Laminated Shim Co.
ACKLER, FLOYD C., factory superintendent, Brunner Mfg. Co.
ACKLES, B. H., manager, The Ray L Co.
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ALVIN, W. C., superintendent, Imperial Brass Mfg. Co.
ANGLIM, JOHN, metallurgist, Nash Motors Co.
BALLMAN, C. A., time study department, Hutto Engineering Co., Inc.
BARKER, V. D., lamp development engineer, Western Electric Co.
BATH, J. CHESTER, vice-president, John Bath & Co.
BAYLESS, R. T., editor, American Society for Steel Treating.
BEAUCHAMP, R. B., tools department, F. B. Stearns Co.
BECKER, LOGAN A., chief engineer, A. P. Schraner & Co.
BEDFORD, FRED J., manager of the lubricating department, Magnolia Petroleum Co.
BELDEN, A. G., chief engineer of the machine division, Norton Co.
BENESCH, F. J., chief of tool standards department, Western Electric Co.
BERNHARD, E. W., manager of automotive equipment division, L. H. Gilmer Co.
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BIRCKELBAW, L. I., engineer in plant department, Hudson Motor Car Co.
BITTING, GEORGE L., director of sales, Bunting Brass & Bronze Co.
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BUCHANAN, HUGH L., chemist, Motor Products Corporation.
BUDA, JOHN, engineer, Resita Steel Co.

BULL, A. A., president and general manager, Handy Governor Corporation.
BULLOCK, WILLIAM E., secretary, American Institute of Weights & Measures.
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BUSHER, O. D., district sales manager, Auburn Automobile Co.
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PARKER, ORREL A., president, Parker Wheel Co.
PARSONS, HARRY N., chief engineer, Strom Bearings Co.
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PATTERSON, C. E., vice-president, Athey Truss Wheel Co.
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RHOADS, P. G., mechanical engineer, J. E. Rhoads & Sons.
RICHARDSON, A. A., Niagara Works engineer, National Carbon Co.
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ROBBINS, H. J., sales engineer, Doehler Die Casting Co.
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ROBONSON, J. D., foreman, Scovill Mfg. Co.
ROCKWELL, STANLEY P., president, Stanley P. Rockwell Co.
RODGER, DAVID W., secretary, Federal-Mogul Corporation.
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SWARTZ, K. W., production manager, Reynolds Spring Co.
SWINK, W. H., production engineer, Lycoming Motors Co.
TABLE, W. E., assistant superintendent, F. B. Stearns Co.
TAYLOR, E. A., works manager, Yellow Sleeve Valve Engine Works, Inc.
THIELICKE, E., Berlin, Germany.
THIERS, FRANK H., production manager, Coleman Lamp Co., Ltd.

THOMAS, R. S., salesman, Norton Co.
TILDEN, P. V., E. I. du Pont de Nemours & Co.
TOGGEN, B. A., district sales manager, Niles Tool Works Co.
TOWSEND, R. A., metallurgist, Van Dorn Iron Works Co.
TROSTER, H. O., time study department, Hudson Motor Car Co.
TRUNDLE, GEORGE T., JR., president, Trundle Engineering Co.
UPHAM, E. W., chief metallurgist, Chrysler Corporation.
VANDEGRIFT, THOMAS C., mechanical engineer, General Motors Corporation Research Laboratories.
VANDERVOORT, F. M., district engineer, Mullins Body Corporation.
VOTH, PAUL H., equipment engineer, Willard Storage Battery Co.
VRAKELOS, GUS, president, The A. C. E. Shop.
WADE, H. E., president and general manager, Fairmont Railway Motors, Inc.
WAGNER, V. W., tester, Studebaker Corporation of America.
WALKER, E. A., mechanical engineer, John Bath & Co.
WALKER, P. H., ceramic engineer, Carborundum Co.
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WERTHER, W. R., chief chemist, Algoma Steel Corporation, Ltd.
WERTZHEISER, JOSEPH, vice-president, Meteor Electric Corporation.
WESTON, W. B., manager of sales, Illinois Steel Co.
WHITESIDE, JOHN E., designer and promoter, Syracuse.
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WHITTEN, O. M., factory manager, Athey Truss Wheel Co.
WILSON, ELMER R., machinist, Chevrolet Motor Co.
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Recovering Oil from Wells

OIL underground is a liquid which contains both dissolved solids and dissolved gas. Vaseline and paraffin wax are among the solids in solution in the oil. Natural gas is also in solution in oil. The amounts of solids and of gases dissolved in oil vary widely in different oil-fields, giving vastly different types of oil. The general principles involved in these liquid solutions are, however, the same. They differ only in the degree with which they may be applied. It is the uncontrolled release of natural gas from oil underground that results in the production of "gushers."

Oil underground is not a simple pool of liquid containing dissolved solids and natural gas. The oil is found in sand or sandstone beds under layers of rock which make a gas-tight dome or cover for the oil reserve. It is not surprising that only small portions of an oil reservoir, in some cases less than one-tenth, are really occupied by oil. In extreme cases, as much as two-fifths of the sandy mass can be oil. Most proved oil-fields show oil contents between these two extremes.

It has been calculated that, with an average sand passing through a 48-mesh, there are, in 1 cu. ft., as many as 1,500,000 pores in which oil may be stored, there are 4300 sq. ft. of sand surface in direct contact with the oil, and the average size of the pore is such that 700 of them placed side by side would measure only 1 in. across. The problem of oil recovery is a problem of drainage of oil from sands of such type. If we have two sands, each containing the same amount of oil, but differing in particle size so that the pores of one are only one-tenth the cross-sectional area of the other, the times required for the same volume of the same oil to flow through each sand would be in the ratio of 10,000 to 1. Since actual measurements of average pore-diameters in different oil-sands show variations as high as 50 to 1 it is not unexpected that different oil-reservoirs show greatly varying rates of drainage. What is more important, however, is the varying rate of drainage with varying pore area in one and the same sand. It is apparent that when drainage of a reservoir first starts, the majority of the oil received will come from the largest pores. As these gradually exhaust, the rate of yield will slow up at a very rapid rate. Thus, if we assume, in a given sand, pore areas in the ratio of 100 to 1, a very conservative estimate, the rate of yield of the same oil from the largest and smallest pores will be in the ratio of 100,000,000 to 1. It is obvious that, if the initial flow from the largest pores is a practicable rate of flow, long before all the oil has been given up by the sand the yield rate will have become negligibly small.

Just as gasoline increases the ease of flow of a heavier oil when mixed with it, so, also, the introduction of natural gas into a heavy oil increases its fluidity. The effect of the natural gas as a thinner for the oil is even more pronounced, weight for weight, than the effect of gasoline. We increase the fluidity twice as much by dissolving twice the amount of gas, or, what is the same thing, by doubling the gas pressure.

NATURAL GAS IN OIL

Crude oil underground is generally heavily charged with natural gas, frequently at pressures as great as 2000 lb. per sq. in. It has been found that a crude oil which contains natural gas dissolved in it at 500-lb. per sq. in. pressure flows just twice as rapidly as it would under the same conditions if it contained no dissolved gas. The effect of maintenance of gas pressure on the fluidity of the oil is two-fold; it increases the rate of yield of oil and also the total amount of yield attainable in practice. Any uncontrolled release of gas pressure will have its effect upon ultimate oil-recovery, but in some cases an apparently large amount of gas must necessarily be produced to win the oil even though by such gas production pressure is reduced.

A natural gas composed principally of methane is less than four-fifths as soluble as a natural gas containing roughly methane and ethane in equal proportions. Attention should be paid not only to maintaining gas-pressure in the oil area but also to the type of gas used for maintenance of the pressure. From the viewpoint of fluidity, a pressure of "rich" natural-gas would be very much better than a pressure of "lean" natural-gas, although economic factors might prevent such a procedure.

It is not essential that the gases used in maintaining pressure be natural gas. Carbonic acid gas is more soluble in crude oil than the better of the two natural gases mentioned above. Neither air nor hydrogen is very soluble in crude oil and their efficiencies could not be expected to be more than a small fraction of those attainable with natural gas or carbon dioxide. In the case of air, also, since chemical reaction may occur between the oil and the oxygen, the results obtained would depend in part on whether these reactions gave more viscous or less viscous products.

Since deep wells are hotter than shallow wells we may expect greater proportionate recoveries of oil from deep wells. There does not seem, however, to be any simple practicable method whereby the temperature of a given well can be increased to give the advantage of greater rate of flow with hotter conditions. Also, the hotter the oil, the less the gas which it will dissolve under a given pressure.

Effect of Surface Tension

Anyone can show the operation of surface tension by allowing the tip of a handkerchief to touch the surface of a bowl of water. Close observation will show that the water is "sucked up" by the handkerchief well above the level of the water in the bowl. The water rises to higher levels in the fine pores of the handkerchief than it occupies in the bowl of water. The scientist measures surface tension in just this way. He measures the height to which the liquid will rise above the level of a liquid, when a fine tube of known bore is introduced into the liquid. The greater the surface tension the higher it will rise. A little soap in water lowers its surface tension and the rise can easily be reduced to half its normal value.

The bed of oil sand is a fine network of tiny pores acting in the same manner as the tube of fine bore or the handkerchief. Drainage from such a sand bed would be incomplete even if all the factors already discussed in detail were not operating at all. There is no room for much work on the surface tensions of oils and their modification by the addition of substances which would lower their surface tensions and thus promote their expulsion from the sand areas. —H. S. Taylor.

Production and Distribution

THE conclusion reached by the Joint Commission of Agricultural Inquiry that the question of distribution is one of the most important economic problems which today confronts the Country seems to be borne out by a study of the facts. While the problem is one that obviously originates with the producer or the manufacturer, its ramifications extend through all of the economic mazes of our commercial transactions and in its final analysis play a vital and important part in the welfare of every individual in the Country.

Fifty years ago mechanical production was in an embryonic state and manpower was the controlling factor in production. Today we live in an age of machines that duplicate the reasoned movements of the individual, save only that the machines are faster and make fewer mistakes. Mechanical wizardry in practically every field of manufacture has resulted in a production which has gained upon and passed consumption.

This over-production, both in agriculture and industry, has brought in its train the pressing necessity for broader markets. People must buy who never bought before, or increase their buying, and to accomplish this, old methods of distribution have been relegated to the scrap heap and new methods have taken their place. On every side, and turn where one will, there is no escape from the insistent demand to buy. And no blame for intensive merchandising can attach to its originators because those who fail to adopt such methods are either pushed to the wall or else struggle along endeavoring with but indifferent success to keep pace with the procession.

Costs More To Distribute than To Produce

Advertising is but one of the methods employed to effect widespread distribution. In some industries the wholesalers and jobbers have been practically eliminated and their niche in the scheme of distribution has been preempted by the manufacturer who, by various methods through the medium of his own organization, handles the distribution of his products.

As Ralph Borsodi, in his excellent book entitled The Distribution Age, points out, since human energy is always paid for, it is obvious that when we buy anything today we are paying proportionately much more for distribution and much less for production than we were 50 years ago. And we read to the same effect in the report of the Joint Commission of Agricultural Inquiry that we have now reached the point where it costs more to distribute and serve than it costs to produce.

If the problem of distribution were one involving merely the transportation of a specific article to a final destination, there to be turned over to the ultimate consumer, the distribution problem would be comparatively simple, but there is no such simple situation with which to contend. It is very difficult to say that this or that step in the distributive chain can be eliminated or perhaps consolidated with some other. Undoubtedly in a great many industries economies may be effected in this manner, but it appears that one of the principal causes of rising costs is to be found at the very end of the distributive chain.

The producer, the manufacturer and the distributor, in an effort to broaden their markets and because of an almost devastating competition, resort to almost any measures which will bring about an increased distribution and consumption of their products. The effect of this on the ultimate consumer is only natural. Catered to on every side with an infinite variety of products, his demands for service complied with almost before they are formulated, it is merely a manifestation of human nature that he should make increasingly expensive demands upon those who serve him.

While economies may be effected in the distributive chain, it is obvious that the consuming public must also be educated to lessen its demands in order to bring about a satisfactory reduction in the distributive costs.—James H. Perkins, president of the Farmers' Loan & Trust Co.

Corrections in the Davidson Paper

Several unfortunate typographical errors crept into the paper by M. W. Davidson on Reciprocating Balance in Engines of Six and Eight Cylinders, which was printed in the September issue of The Journal beginning on p. 315.

Mr. Davidson's initials are M. W. instead of M. V. as printed. The letter *I*, which appeared in Fig. 1 as the dimension defining the vertical height of the crankpin center above the line of the engine, should have been shown as letter *H*.

On p. 316, in the second line following the word "Let" in the first column, for RW^2 substitute RW_1^2.

In equation (16) on p. 316, the denominator of the first term of the parenthesis should be raised to the 3/2 power instead of reading as printed with a subscript 2.

On p. 318, equation (38), A^2 should be written A_2.